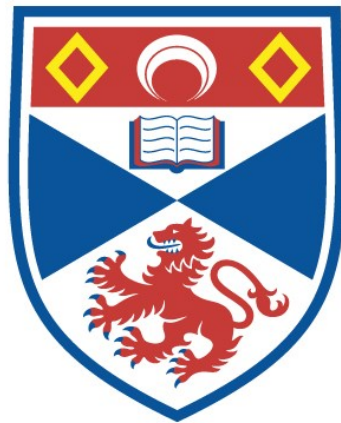


**INHIBITORY PROCESSES IN THE MISINFORMATION
EFFECT: NEGATIVE CONSEQUENCES OF AN ADAPTIVE
PROCESS**

Jo Saunders

**A Thesis Submitted for the Degree of PhD
at the
University of St Andrews**



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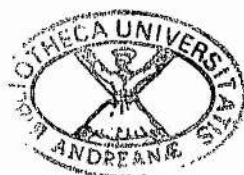
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Submitted in fulfilment for the degree of PhD

University of St. Andrews, September 2003

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ABSTRACT

Recent research has suggested the seemingly ironic possibility that in order to be able to remember effectively, we must be able to forget. Despite the fact that forgetting is typically conceived of as a wholly negative experience it may, nonetheless, have adaptive consequences for the efficient updating of memory. Without a method for setting aside out-of-date or unwanted information, we may be unable to satisfy current memorial goals. Recent research suggests that inhibitory processes operating during retrieval may be responsible for the temporary forgetting of unwanted information so that desired memories can be successfully retrieved (referred to as *retrieval-induced forgetting*, M.C. Anderson, Bjork & Bjork, 1994).

The present thesis attempts to enhance our understanding of the basic mechanisms that underlie our ability to update our memories by examining the role of inhibitory processes in the misinformation effect. The misinformation effect is a form of memory error whereby individuals mistakenly report post-event misleading information rather than information that was originally encoded during an initial study phase (e.g., E.F. Loftus, 1979a). In order to examine whether the underlying mechanisms in the misinformation effect (and more generally in memory updating) are inhibitory in nature, five theory-driven experiments were conducted and reported in this thesis.

An inhibitory account of misinformation effects assumes that significant misinformation effects should only be detected when information from an initial event has been inhibited, and therefore is unavailable to conscious inspection. A new paradigm was designed for investigating the memorial processes responsible for the misinformation effect, which combined key features from the retrieval practice

paradigm with that of the misinformation paradigm (cf. E.F. Loftus, Miller & Burns, 1978). In Experiments 1 and 2, the boundary conditions of varying the retrieval status of target items within this new paradigm were explored. More specifically, in Experiment 1, significant misinformation effects were found only when misleading information was presented on items that were subject to retrieval-induced forgetting, i.e., the original information was unavailable to conscious inspection, leaving only the post-event information available for retrieval. A further test of the retrieval-induced forgetting account was examined in Experiment 2 whereby the presence of retrieval-induced forgetting was manipulated through the insertion of a delay. Experiment 2 indicated that the production of misinformation effects was dependent on retrieval-induced forgetting remaining active (i.e., under condition of no delay, or where a delay occurred between study and retrieval practice). In contrast, significant misinformation effects were not found when retrieval-induced forgetting dissipated over a retention interval (i.e., when a delay was inserted between retrieval practice and final test).

Despite Experiments 1 – 2 suggesting that retrieval-induced forgetting may play an influential role in the production of misinformation effect, the new misinformation paradigm cannot differentiate between the possible inhibitory and non-inhibitory processes that may underlie retrieval-induced forgetting. This is primarily due to the new paradigm employing a free recall test rather than using a memory test that can separate the actions of inhibitory from non-inhibitory processes. However, as the 'independent probe' method (M.C. Anderson & Spellman, 1995) can perform this task, it was modified for use in Experiments 3 – 5, which more closely examined whether inhibitory processes were indeed responsible for both retrieval-induced forgetting and misinformation effects. More specifically, Experiment 3

found that inhibitory processes were the primary mechanism behind retrieval-induced forgetting, while Experiment 4 demonstrated that any item that competes with target material for retrieval is subject to inhibition (referred to as cross-category and second-order inhibition). Experiment 5 extended the findings of Experiment 3 and 4, and found that inhibitory processes were not only responsible for misinformation effects, but that all inhibited information is susceptible to the effects of post-event information. The present studies suggest that that an adaptive function on inhibition (i.e., the updating of memory) may be responsible for unwanted and undesired effect in memory under certain circumstances (i.e., the production of misinformation effects and eyewitness errors).

In order to examine more fully the role of inhibitory processes in the production of misinformation effects, and more generally, in memory updating, the present thesis considers both classical and modern research on forgetting. Chapter 1 outlines recent theorising that forgetting should not be considered an exclusively negative phenomenon, and that it should, in fact, be considered an essential and necessary process that keeps our memory systems running optimally. This possibility is examined in more thorough detail in Chapters 2 and 3. Chapter 2 considers both classical interference research, and the more recent inhibitory accounts of intentional forgetting, while Chapter 3 examines how successful these inhibitory accounts have been applied to research concerning unintentional forgetting. In contrast, Chapter 4 examines a rather different approach to memory updating as viewed through misinformation studies. A new paradigm for investigating misinformation effects is introduced in Chapter 5, and the empirical Chapters 5 – 9 discuss the application of this new paradigm to the investigation of misinformation effects. Finally, the conclusions and implications of unintentional forgetting for theories of memory

updating are discussed in Chapter 10. The work presented in this thesis suggests that not only can inhibition promote the updating of memory, but it can also leave our memories vulnerable to the unintentional integration of incorrect information.

CHAPTER 1

THE ADAPTIVE SIGNIFICANCE OF FORGETTING THROUGH INHIBITORY
CONTROL

It is argued in the current chapter that the psychological enquiry into how honest errors in memory are made has largely ignored the mechanisms that underlie normal memory updating. However, the increasing acceptance of inhibitory accounts of retrieval processes has seen a recent proliferation in research examining the possible adaptive benefit of inhibitory mechanisms in memory updating. Specifically, the present chapter considers the possibility that inhibiting unwanted memories may provide a positive feature to forgetting. However, there are a number of potentially negative consequences associated with material that has been forgotten, and the current chapter briefly considers some of these.

Forgetting as an Adaptive Function of Memory

For most of us, forgetting is typically conceived as a distinctly and intuitively negative experience that continually disrupts our cognitive lives. Such forgetting appears to occur irrespective of how motivated we are to recall information or how inconvenient it might prove if we were unable to bring a desired memory into conscious awareness. Not only do desired memories seem to reside (often frustratingly so) just beyond our reach, but similar episodically- or semantically-related unwanted information can be recalled instead. Accompanying the recall of erroneous material is the feeling that we would be able to recollect the desired memory if only we could set aside the impostor. Thus, life would seem easier if we

never suffered from the frustrating and sometimes embarrassing situation of forgetting.

However, in many instances, forgetting is exactly what is needed to keep our memory systems up-to-date and to keep the retrieval process running optimally. Not only do we need a process for setting aside out-of-date information, but we also need a process that can prevent related, but unwanted, information from interfering with the retrieval of target material (M.D. MacLeod, Bjork & Bjork, 2003). This ability to selectively retrieve a target from a field of similar competitors seems a highly desirable feature of memory that would suggest an adaptive role to forgetting. Given this possibility, forgetting may have arisen as an adaptive response to the seemingly limitless storage capacity of memory that contrasts with an imperfect and limited retrieval system (R.A. Bjork, 1989; R.A. Bjork & Bjork, 1992). While we seem to be adept at storing information, especially that which we can understand in terms of our current knowledge and schemas, we often experience difficulties in gaining access to specific information and bringing it into conscious awareness.

Complementing these observations, recent research suggests that forgetting may play an adaptive role in memory via the goal-directed forgetting of unwanted and out-of-date information. Not only can this forgetting function be seen as a relatively unintentional consequence of the retrieval process (e.g., retrieval-induced forgetting), but we can also attempt to set aside information intentionally (e.g., suppression). Irrespective of whether information can be set aside intentionally or not forgetting may allow us to update our memories in a relatively quick and efficient manner without erasing the out-of-date or unwanted information. In contrast, if we were unable to selectively access a target memory by setting aside the multitude of related

memories, we would experience difficulties in recalling our desired memory. Thus, in effect, we need to be able to forget in order to be able to remember.

Inhibition: Describing an Empirical Phenomenon or asserting the Presence of a Mechanism?

While past theories of forgetting have explained retrieval failures through exclusively non-inhibitory processes that exert their influence on retrieval cues and retrieval routes, recent theories suggest that forgetting can also be due to the actions of inhibitory processes acting at the level of the memorial representations. More specifically, an increasing number of researchers have suggested that a specific type of inhibition may be present in memory, namely retrieval inhibition (e.g., M.C. Anderson & Bjork, 1994; E.L. Bjork & Bjork, 1996; E.L. Bjork, Bjork & Anderson, 1998; E.L. Bjork, Bjork & MacLeod, in press; Geiselman, Bjork & Fishman, 1983; Macrae & MacLeod, 1999). It is thought that retrieval inhibition may represent a set of mechanisms that prevents or reduces retrieval access to certain items without affecting the overall availability of those items in memory (Tulving & Pearlstone, 1966). In addition, retrieval inhibition is also thought to control not only intentional forgetting (e.g., M.C. Anderson & Green, 2001; E.L. Bjork & Bjork, 1996), and thus our deliberate attempts to update memory, but is also thought to underlie certain types of unintentional forgetting (e.g., E.L. Bjork et al., in press; M.D. MacLeod et al., 2003), allowing it to satisfy the requirements of a flexible and adaptive goal-directed forgetting mechanism.

However, there are some difficulties with the use of the term inhibition in any theory of remembering and forgetting. In the past, the term inhibition has been used in many ways within the memory literature to describe very different effects. At its

theoretically weakest, retrieval inhibition merely refers to an empirical finding that is the opposite of facilitation (M.C. Anderson & Bjork, 1994; R.A. Bjork, 1989). Similarly C.M. MacLeod, Dodd, Sheard, Wilson & Bibi (2003) have suggested that any empirical finding that demonstrates a decrease in performance compared to the baseline should be considered a theoretically weak form of inhibition. Thus, inhibition is being used as a descriptor of a pattern of memory performance rather than ascribing the presence of inhibitory processes. In fact, empirical findings of such types of 'inhibition' can be accounted for exclusively in terms of the strength-dependent competition assumptions of non-inhibitory processes. These non-inhibitory theories assume that items that share a common cue compete with one another for retrieval, and strengthening the association between one item and its cue (typically the target item) results in a weakening of the association between that cue and the remaining competing items. This definition of retrieval inhibition can be seen throughout the interference literature, although it is typically referred to as interference or impairment (see also C.M. MacLeod et al., 2003), and appears to be primarily due to impairment occurring at the level of the retrieval cue or the retrieval route. These interference effects, and the non-inhibitory processes that are believed to underlie them, are discussed in more depth in Chapter 2.

Retrieval inhibition, however, can be used in a more mechanistic sense to suggest the de-activation or reduction in activity of a memorial representation through the actions of inhibitory processes. However, despite mechanistic retrieval inhibition implying the actions of inhibitory neurons, it remains unclear as to whether they are really involved, or whether "inhibition is (only) to be taken metaphorically" (M.C. Anderson & Bjork, 1994, p. 313). While individual inhibitory neurons acting on memorial representations do not appear to be involved, groups or networks of neurons

may represent an item in memory and the inhibition of some of these neurons may produce retrieval inhibition (M.C. Anderson & Bjork, 1994). Similarly, retrieval inhibition may be an example of multiple neurons acting together, producing a collective inhibitory effect. Another possibility is that inhibitory neurons are not just activated once, but are, in fact, activated repeatedly in order to sustain the inhibition of certain representations – perhaps to prevent a rebound effect that would make these unwanted memories become hyperaccessible (see M.C. Anderson & Bjork, 1994, for further discussion on these latter points). The success of applying inhibitory mechanisms to account for forgetting is examined in more depth in Chapter 3.

The Evolution of Inhibitory Processes and their Acceptance in Theories of Memory and Cognition

The role of inhibitory mechanisms as an explanation of higher-order cognition is not a new concept. The actions of both excitatory and inhibitory neurons can be found in the nervous systems of animals ranging from single-celled organisms to humans, suggesting that inhibition is a fairly basic function of any organism's nervous system. The role of inhibition in higher cognition in humans is thought to have evolved as a response to social pressures that allowed humans to withhold aggressive and emotional responses. The ability to suppress these behaviours is thought to have encouraged co-operation within groups while similarly promoting competition between groups, which, in turn, led to the enlargement of the frontal cortex and an increase in neural connections between the frontal lobes and the limbic system. With this increase in frontal cortex volume came greater inhibitory control over aggressive behaviours, which led to larger social groups. The increase in inter-dependence within groups, and the increase in competition with out-groups, further increased the

ability of humans to inhibit unacceptable behaviours on a voluntary basis. This cycle of influence of social factors on inhibitory control of aggressive behaviours, and vice versa, continued and evolved to allow inhibitory control over other lower- and higher-order social and cognitive behaviours (see Bjorklund & Harnishfeger, 1995, for further discussion).

It is not just inhibitory mechanisms that have evolved, however, but also theorists' acceptance of their role in human behaviour and cognition. While many researchers accept that inhibitory mechanisms probably play a role in many higher-cognitive actions, empirical demonstrations of inhibition in action remain ambiguous. For example, the prefrontal cortex is believed to regulate inhibitory control because damage to the frontal lobes can result in an inability to inhibit unwanted and irrelevant responses to stimuli, called 'disinhibition' (Luria, 1966). Disinhibition can result in a variety of cognitive disorders that are collectively known as dysexecutive syndrome (Baddeley, 1986), which are characterised by impairments in planning, monitoring, initiation, organisation, and perseveration. However, while frontal lobe damage can cause disinhibition in cognitive behaviours, the task of pinpointing the role of inhibitory neurons, or groups of inhibitory neurons, is a difficult one. Thus, overcoming these difficulties in order to put forward the possibility that inhibitory mechanisms can be responsible for cognitive behaviours is a complex task.

Until very recently, inhibitory mechanisms have also played little role in theories of memory, partly due to the difficulty in demonstrating that inhibitory mechanisms underlie empirical inhibitory effects, and partly because of its potential association with psychoanalytic theory (e.g., R.A Bjork, 1989, 1998), and the repressed memory therapy movement (E.F. Loftus & Ketcham, 1994; Ofshe, 1992). The notion that individuals could intentionally inhibit or suppress memories from

conscious awareness is one of the most basic premises of Freud's psychoanalytic theory (Freud, 1915), although Erdelyi (1993) asserts that Anna Freud argued that repression could also take place at an unconscious level. However, it is interesting to note that confusion over the term repression nicely mirrors that of retrieval inhibition (Erdelyi, 1993).

It has also been suggested that the notion of inhibition in memory was incompatible with the computer metaphor of information processing that was prevalent in psychology from the 1950s through to the end of the 1970s (e.g., Johnson-Laird, 1977). As R.A. Bjork (1989) noted, researchers were poorly served by the computer metaphor, which has led us to think of human memory "in terms of processes like storing, scanning, grouping, erasing, and so forth. Notions like inhibition, suppression, unlearning, and spontaneous recovery are not easily compatible with the computer metaphor" (R.A. Bjork, 1989, p. 310). As such, the human memory system has little in common with that of artificial memory devices.

The proliferation of facilitatory processes during the 1960s and 1970s also prevented the rise of inhibition as an explanatory account of various cognitive behaviours. This meant that empirical inhibitory effects were explained as being the result of more than one facilitatory process making use of the same resources. For example, the fact that the Stroop effect could be explained as the activation of two similar representations in competition against each other made it difficult to choose to argue for a role for inhibition.

Despite the delay in accepting an inhibitory account, many theories of cognition in recent years have asserted the presence of inhibition, including language comprehension (e.g., Gernsbacher & Faust, 1991), visual selective attention (Tipper, 2001), fact retrieval e.g., M.C. Anderson & Bell, 2002), executive functions such as

task switching (e.g., Mayr, 2002) and the stopping of thoughts and behaviours (Logan, 1994). Similarly, as inhibitory mechanisms have been incorporated into models of normal cognition, a loss of inhibitory control has also been suggested in clinical disorders, such as obsessive-compulsive disorder (Enright & Beech, 1993), schizophrenia, frontal lobe syndrome (Schacter, Moscovitch, Tulving, McLachlan & Frendman, 1986), hyperactive attention deficit disorder (Schachar & Logan, 1990), and amnesic syndrome (Bäuml, Kissler & Rak, 2002). A gradual loss of inhibition has also been suggested to underlie changes in cognitive abilities in normal ageing (e.g., Hasher, Stoltzfus, Zacks & Rypma, 1991), while a loss of inhibition in the extreme may underlie some of the symptoms associated with Alzheimer's disease (e.g., Faust, Balota, Duckek, Gernsbacher & Smith, 1997).

The current thesis will focus on the role of inhibitory processing in memory retrieval and memory updating. Inhibitory mechanisms have previously been suggested to operate within both semantic (e.g., Blaxton & Neely, 1983; Dagenbach & Carr, 1994), and episodic memory (e.g., M.C. Anderson & Spellman, 1995). For example, Dagenbach and Carr (1994) have suggested that inhibitory processes may be a necessary feature for memory updating within semantic memory networks in order to counteract the effects of spreading activation. Dagenbach and Carr wondered how updating occurred within the semantic memory system, and how newly acquired information could be accessed as it was being integrated into the system, given that semantic memory consists of well-learned stable memorial representations. Any memory updating system must find a critical balance between flexibility and stability within the system. If the system is too inflexible it will be unmodifiable and newly encountered information will fail to be integrated into memory. Similarly, if the system were easily updated then any newly encoded information would displace older

information, even if this newer information were blatantly false, leading to an unstable system that would be prone to erratic and extreme changes in storage and retrieval. While there are instances of this latter point, such as reading spelling errors making it difficult to determine the correct spelling (e.g., Jacoby & Hollingshead, 1990), the integration of new semantic information with older information appears to be a much slower process (Dagenbach, Horst & Carr, 1990).

Dagenbach and Carr (1994) suggested that an exclusively facilitatory account of new learning in semantic memory might be problematic if this new learning only occurred relatively slowly. This is primarily due to newly learned items being fairly weak compared to the strength of older information. As a result, the retrieval of newer items may be at risk from blocking, which might occur through the spreading of activation from stronger items. Thus, Dagenbach and Carr propose that inhibitory processes may provide a mechanism by which memory can be updated, that not only allows the newly encoded information to remain available for retrieval during integration, but also prevents stronger representations from blocking the retrieval of newer items. It achieves this by suppressing similar representations, especially stronger ones, which might interfere with the retrieval of the desired representation (Dagenbach, Carr & Barnhart, 1990).

Negative Consequences of Forgetting

While the inhibition of information has recently been advanced as a necessary function of memory (e.g., E.L. Bjork et al., in press; E.L. Bjork et al., 1998; R.A. Bjork, 1989; Macrae & MacLeod, 1999), it can also have a number of unintended negative consequences. Any material that cannot be brought into consciousness is likely to be unable to influence current thoughts, decision processes or behaviours, or

be in a vulnerable position, and be displaced by other information. While information that is deliberately banished from conscious awareness is perhaps less likely to have negative consequences, there is an interesting exception. Wegner and colleagues have found that trying to suppress a thought or memory intentionally can have the opposite effect, that is, the item becomes *hyperaccessible* (e.g., Wegner & Erber, 1992). Thus, individuals who have attempted to suppress a thought find themselves thinking of it during the episode of suppression as well as afterwards. Gold and Wegner (1995) have suggested that attempting to inhibit a single thought or memory is an almost impossible task, and “we end up placing a marker on the very thought we are trying to bury” (Gold & Wegner, 1995, p. 1254).

In contrast, there is increasing evidence that the unintentional forgetting of information through new learning or the retrieval of already encoded information may have several unintended consequences on cognitive behaviours. For example, using a mock exam context, Macrae and MacLeod (1999, Experiment 2) demonstrated that even though participants were motivated to recall all the information from the study phase, they were unable to overcome the inhibition of previously unwanted items. Similarly, participants have been unable to ‘release inhibition’ in mock eyewitness contexts (M.D. MacLeod, 2002; Shaw, Bjork & Handel, 1995), while Dunn and Spellman (2003) have found that both stereotypical and individuating information about individuals can be unintentionally inhibited. Although the ability to suppress stereotypes may be beneficial for our ability to interact in socially desirable ways with others, especially out-group members, the unintended inhibition of individuating information may actually maintain our stereotypic beliefs.

Unintentional Consequences of Forgetting: Inhibitory Processes in the Reporting of Misleading Post-event Information

As this prior research suggests, there can be numerous negative consequences to both intentional and unintentional forgetting. In the case of unintentional forgetting, these negative consequences can include not only the omission of information, such as in examination situations (M.D. MacLeod & Macrae, 1999, Experiment 2), and eyewitness events (M.D. MacLeod, 2002; Shaw et al., 1995), but also in terms of our thoughts and behaviours via the manipulation of memory availability (Dunn & Spellman, 2003). In the latter case, where our ability to access stereotypic and individuating information varies, it would seem that we can report potentially unwanted information in place of more desirable information – and we seem to be unaware of such mistakes.

In other areas of research, such as the misinformation effect, we may also unsuspectingly report unwanted information due to the inhibition of desired memories. Misinformation effects are a form of memory error whereby individuals have a tendency to report a piece of post-event information in place of an original study item. As misinformation effects are typically induced through the presentation of contradictory information about a previously studied event, the misinformation effect resembles the type of memory updating scenario whereby conflicting information is integrated into an established memory. As the misinformation effect is also examined through the use of complex visual materials, and the explicit introduction of contradictory information, it provides an alternative method of examining memory updating to that typically employed through studies of forgetting. However, despite the misinformation effect providing the opportunity to examine the underlying memorial processes involved in the updating of memory, surprisingly little

research has actually done so. Research examining misinformation effects has instead primarily focused on questions concerning the permanency of memory. More specifically, researchers have debated whether memory is updated through a destructive updating mechanism (e.g., E.F. Loftus, 1979a), by which the older original memory is permanently erased, or whether this older information continues to reside in memory after the encoding of contradictory information (e.g., Christiaansen & Ochalek, 1983; Lindsay & Johnson, 1989a, 1989b). Thus, this rather myopic view of misinformation effects has resulted in the underlying mechanisms that control this interplay between old and new memories being largely ignored. If older traces are destroyed or altered during memory updating, how does this occur, and conversely, if older memories continue to coexist after the encoding of newer information, how is this newer information reported without also accessing the older trace? It is conceivable that inhibitory processes may provide a mechanism by which post-event misleading information can be reported in place of the correct details that were encoded during an initial study phase. If information from a target event were to be inhibited, and thus were unavailable to conscious inspection, could conflicting details be integrated into memory for that event, resulting in the reporting of those incorrect details? Given that the forgetting of information may provide a method of examining the misinformation effect, this thesis more closely considers the role of retrieval inhibition in the production of misinformation effects.

CHAPTER 2

STRENGTH-DEPENDENT COMPETITION MODELS OF INTERFERENCE AND
THE ADVANCEMENT OF RETRIEVAL INHIBITION

If asked, many of us would say that the biggest problem with our memory is that we forget, and that we usually forget things that we would rather remember. Whether we forget someone's name, a telephone number, or where we parked the car, forgetting is typically seen as an irritating and annoying feature of memory. The present chapter considers seminal research, as well as current theories of memory, which suggest that forgetting may actually be a necessary function of memory in order to allow us to retrieve information from long-term memory with relative ease and accuracy. Classic studies are considered which suggest that forgetting unwanted or distracting information can help us complete current memorial goals. More recent theories are also examined, which suggest that we can voluntarily set aside unwanted information so that we can retrieve desired memories. Thus, forgetting can be seen as a process that may allow the updating of our memory systems with new information that can be achieved either through the deliberate setting aside of unwanted information, or through more automatic processes.

Classical Interference Era

During the classical interference era, interference was typically defined as a retrieval failure brought about through the learning of new information that was related to material currently targeted for retrieval. Research into retrieval interference has contributed greatly to our understanding of how memory works, as well as how and why forgetting occurs. Principles learned as long ago as the beginning of the 20th

century still provide the foundation of current and newer conceptions of how we account for the phenomenon of forgetting, such as McGeoch's (1936, 1942) basic argument that items compete for retrieval access through a shared cue. However, while most accounts of interference agree on key assumptions concerning why retrieval interference occurs, they do differ on how these retrieval failures come about.

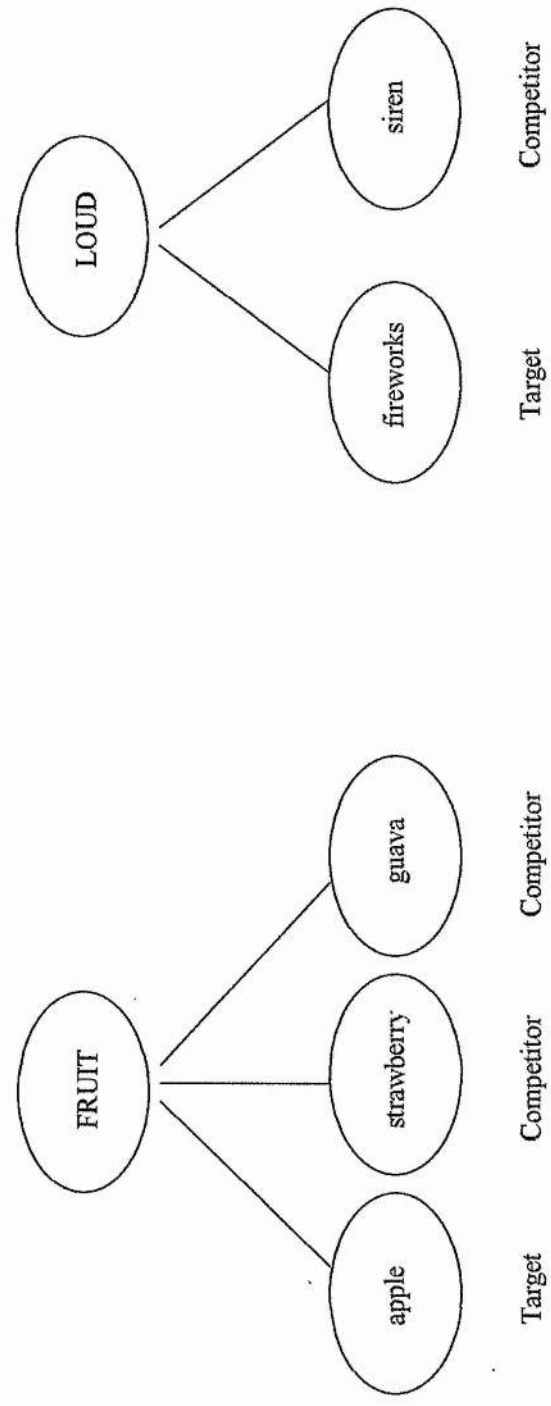
Nevertheless, these accounts do share some basic assumptions about how the retrieval process typically works. There is general consensus, for example, that the retrieval of a target from memory is the result of the progression of some form of activity from a retrieval cue, along the retrieval route, through to the target. Retrieval cues come in many forms, ranging from simply presenting the first letter of the target (e.g., O _____), to presenting fragments of the target memory (e.g., ORA ____), to a category label (e.g., FRUIT), or even contextual details that were present at the time of encoding (e.g., the smell of oranges). Similarly, the successful retrieval of a target memory is dependent on the quality and quantity of retrieval cues. Typically, the more general the retrieval cue, the less likely the target memory will be retrieved as these general cues are non-specific to a target and are likely to activate many related item in memory. In contrast, retrieval success is more likely if more specific cues are employed that are related to only a small sub-set of items. In addition, employing multiple cues is more likely to result in a successful retrieval attempt than employing only a few cues. However, cues are not the sole property of the retrieval process that may influence the retrieval of a target. Retrieval routes that are associated with retrieval cues play an influential role as well. When a memory is highly associated to a retrieval cue then the retrieval route is likely to be strong, and thus the target item is more likely to be recalled. In contrast, when the retrieval route between a retrieval

cue and a target is weak then the target is less likely to be retrieved, and instead, a related item that is more strongly related to the cue may be mistakenly retrieved.

The Competition Assumption

It is in this situation, where a cue is related to multiple target items, that interference is thought to come into effect (McGeoch, 1936, 1942). These unwanted but related items are typically referred to as *competitors* or *competing items*, which aptly describes the interference created during the retrieval process with the target material. These unwanted items are thought to compete for retrieval with the target, a process sometimes referred to as the competition assumption (M.C. Anderson, Bjork & Bjork, 1994), which leads to competitors interfering with the retrieval of the target. Thus, any impairment in the retrieval process that is caused by these competitors is interference. The more competitors that are associated with a cue, the more interference is created, leading to progressively slower retrieval and more retrieval failures (J.R. Anderson, 1974; Watkins, 1978), see Figure 1. As a result, the more specific a cue is, the fewer competing items will be accessed and the smaller the interference effect is likely to be. In addition to the role that specified retrieval cues play in minimising the interference of competitors, the association between the cue and the target compared to the strength of association between competitors and that cue also play an influential role. Typically, retrieval of a target is more likely if the association between a retrieval cue and the target is a strong one (i.e., the item is highly associated with the retrieval cue), and is stronger than the association between that cue and the competing items. Thus, the use of sufficiently specified cues that are strongly associated to a target are more likely to identify a specific target than more general cues that are only weakly related to the target.

Figure 1: Competition assumption in non-inhibitory theories



Note. The competition assumption predicts that the greater the number of items that are associated to a cue the greater the competition. As this competition for retrieval between items increases so does the magnitude of interference. In the example on the left, the competitors have a combined strength greater than the example on the right. Thus, there is greater interference in the diagram on the left than on the right.

Maximising Competition: The Paired-Associate Paradigm

Many of the assumptions concerning the impact of competitors on retrieval of a target come from classic interference paradigms designed to maximise the effects of interference. Interference is maximised through manipulating three factors that influence the interference effect: (1) the cues that individuals associate a target to; (2) the cues that individuals use to aid recall; and (3) the number of other items that are associated with that cue. The basic interference paradigm, that of the paired-associated paradigm, manipulates all three of these factors, and has been varied in different ways in order to study a variety of interference phenomena.

The paired-associate paradigm takes the form of list learning exercises, whereby participants learn new responses (i.e., items) to stimuli (i.e., cues). Participants are presented with lists of word pairs, where one word is paired with another unrelated word. These word pairs are studied to such a degree that, when the first word is presented, it cues the second word. This new learning should foster the encoding of associations between the stimulus and the response, and vice versa, as well as encoding background information (e.g., the association of the word pair to the whole list). Typically, participants learn one list of paired-associates (e.g., A-B), followed by a second list (e.g., A-D), where the responses on this list are related to stimuli from the first list. By associating the stimulus term (i.e., A term) from List 1 with response terms from both the first (i.e., B term) and second list (i.e., D term), the effects of learning a new set of responses on the initial list can be measured.

The A-B, A-D paradigm is the most widely used stimulus-response combination, where the second list (A-D) shares stimuli with the first list (A-B), but differ in responses. It is this sharing of the stimulus with more than one response that is expected to maximise interference effects in memory and can reveal the most to us

about competition at retrieval. Other popular paired-associate paradigms include the A-B, C-B paradigm whereby the two lists share responses but differ in stimuli, and the A-B, C-D paradigm where both lists differ in both stimuli and responses. The A-B, A-B paradigm is also used and sees the second list being identical to the first list and is therefore a paradigm that examines repetition effects in memory.

Outside of these manipulations to the stimuli and responses, varying the testing phase can also inform us about competition in memory. Prior to 1959 the most common testing procedure was the modified free recall task (Underwood, 1948a), which was not a true free recall task, but was in fact a cued-recall task. In the modified free recall task, participants were presented with the stimulus and had to write down the first response that came to mind. Only one response was allowed for each stimulus and it was inconsequential which list the item was retrieved from. The modified recall task was superseded by the modified modified free recall task (Barnes & Underwood, 1959). Again, this task was actually a cued-recall task whereby participants were presented with the stimulus and asked to recall all the items they could think of from the lists that were associated with the stimulus. This task more accurately measured the contents of conscious awareness than did the modified free recall task.

Retroactive Interference

Retroactive interference is probably the most studied phenomenon within the classical interference era and is a form of memory impairment induced by new learning (e.g., the D responses from List 2) between the initial encoding of target information (e.g., the B term from List 2; see figure 2) and its eventual retrieval. This period of new

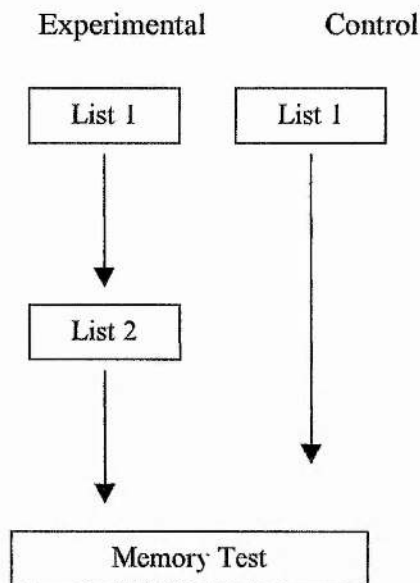
learning is thought to interfere with the retrieval of the original target material (e.g., A-B), leading to impaired recall of responses from List 1.

The magnitude of the retroactive interference effect is dependent on several factors that are manipulated within the paired-associate paradigm. Large retroactive interference effects are typically found when the modified free recall test is employed, as well as when two different responses are associated to the same stimulus, such as in the A-B, A-D paradigm (Underwood & Postman, 1960). These two features of the paired-associate design maximise the competition between responses in List 1 and List 2 that share a retrieval cue, and support the competition assumption of interference theory. However, small interference effects are still found when two different stimuli are used, such as in the A-B, C-D paradigm (McGovern, 1964), which suggests that competition for retrieval is not always a necessary condition for interference to affect the retrieval of target information.

Retroactive interference effects are also reduced or even eliminated when recognition tests are used, which suggests that new learning does not permanently erase or alter older information (Postman & Stark, 1969, but see Chandler, 1989, 1993). This reversal of retroactive interference is in stark contrast to the impaired recall performance on the modified free recall and modified modified free recall tests, implying that recognition tests reduce or eliminate the type of competition that occurs at retrieval in these recall tests. Similarly, retroactive interference effects dissipate as the retention interval between List 2 and final recall increases. This recovery from interference takes the form of increased recall of List 1 items and is referred to as *spontaneous recovery*. This spontaneous recovery of the B responses from List 1 has been found with both the modified free recall test that maximises retrieval competition (Underwood, 1948a, 1948b), and with the modified modified free recall

test (Barnes & Underwood, 1959; Wheeler, 1995). However, some researchers have failed to find a spontaneous recovery effect (Abra, 1967; Birnbaum, 1965), or only very small effects (Koppelaar, 1963; Slamecka, 1966).

Figure 2: Measuring retroactive interference in the paired-associate paradigm



Note. In the retroactive interference paradigm above, participants in the experimental condition receive two lists before completing a memory test, while participants in the control condition receive only the first list before completing the test. When measuring retroactive interference, recall of items from List 1 is compared with the recall of List 1 items in the control condition.

Proactive Interference

Proactive interference occurs when previously learned information impairs our recall for newly acquired material, and thus can be considered the reverse of retroactive interference. The experimental method for investigating proactive interference follows a similar method to that for retroactive interference except for participants in

the experimental condition only being tested on paired-associates from List 2 (see Figure 3). Participants demonstrate proactive interference when recall for List 2 responses is poorer than recall for List 2 in the control.

Variations in the paradigm and in the degree of relatedness between the two lists affect the magnitude of proactive interference in a similar manner to that of retroactive interference. Impaired recall of second list responses is greatest when both lists share retrieval cues (e.g., A-B, A-D), as well as when recall is tested rather than recognition, and when a long delay occurs between the initial encoding and final recall (Postman, Stark & Fraser, 1968; Underwood, 1948a). Thus, while retroactive interference is typically found at shorter retention intervals, proactive interference is more likely to be found at longer retention intervals (e.g., Postman et al., 1968).

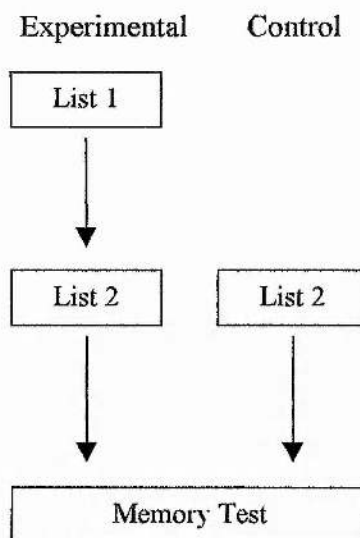
Research on both retroactive and proactive interference contributed greatly to our understanding of the influential role that competition at retrieval plays in controlling the content of our memories. Both fields of research support McGeoch's (1936, 1942) original assumption that interference results from competition for retrieval between items that share a common cue. However, competition between items is not the only factor that influences the retrieval process. The strength of the association between the stimulus and the target response, as well as the strength between that same stimulus and competing responses, also plays a role.

The Strength-Dependent Assumption

The strength-dependent assumption explains retroactive interference as being the result of changes in the strength of association between stimulus and target responses compared to changes in the strength of association between competing responses and the stimulus (M.C. Anderson & Bjork, 1994; M.C. Anderson et al., 1994; M.C.

Anderson & Neely, 1996). This assumption asserts that responses that are highly associated to the stimulus will create the most competition at retrieval and, in turn, will create the most interference in the retrieval of the target response. As a result of the increase in strength of association between one stimulus and response pairing, the strength of other responses association to the stimulus will decrease.

Figure 3: Measuring proactive interference in the paired-associate paradigm



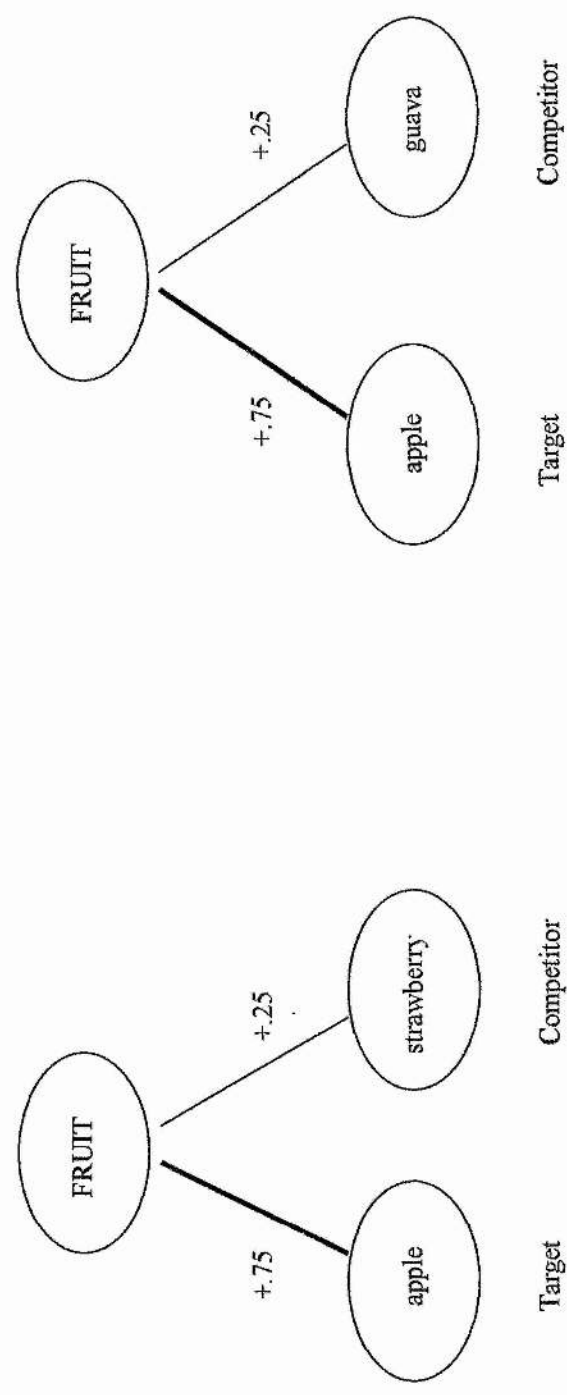
Note. In the proactive interference paradigm, participants in the experimental condition receive two lists before completing a memory test, while participants in the control condition only receive the second list before completing the test. When measuring proactive interference, recall of List 2 items in the experimental condition is compared with recall of List 2 in the control.

This strength-dependent assumption is based on McGeoch's (1936, 1942) observation that interference is greatest under conditions that promote intense competition among responses, such as in the A-B, A-D paradigm, and under modified free recall conditions that only allow one response to be reported for each stimulus.

In this paradigm, the B and D responses are both associated with the same stimulus, resulting in both responses competing and interfering with each other in an attempt to gain retrieval supremacy. While the response that won this competition would be rewarded with its retrieval, the losing item would be subject to what McGeoch called *reproductive inhibition*. The strength-dependent assumption explains retroactive interference as being the result of strengthening the association between the stimulus and new responses (i.e., A-D), which leads to a weakening of the association between the previously learned A-B stimulus-response pairing. Thus, when memory for the A-B association is tested, the stronger A-D associations will continually intrude into memory reports. Similarly, strengthening the A-D association through additional learning will also lead to greater impaired recall of the initial A-B stimulus-response pairings, see Figure 4.

Strength-dependent assumptions concerning retrieval have not only influenced classical interference accounts of retrieval failures, such as occlusion, but have also formed the foundation of modern theories of interference as well as models of how memory is organised. These theories and models assume that successful retrieval is determined by the strength of association between a cue and the desired target relative to the strength of the associations between that cue and all other competitors. For example, the SAM model (Mensink & Raaijmakers, 1988; Raaijmakers & Shiffrin, 1981), and J.R. Anderson's (1983) ACT model are all based on this strength-dependent assumption.

Figure 4: Strength-dependent assumption in non-inhibitory theories



Note. Strength-dependent assumption predicts no difference in degree of impairment of competing items, despite the competitor in the example on the left being of a higher taxonomic strength than the competitor in the example on the right. This is due to the degree of impairment being primarily due to the strengthening of the target. Thus, if the target is strengthened to the same degree, then each competitor in both examples should be impaired to the same degree.

Part-set Cueing

Another interference phenomenon that is based on the strength-dependent assumption is part-set cueing (e.g., Nickerson, 1984; Rundus, 1973). In the part-set paradigm, participants learn a list of items that belong to various categories, followed by an immediate category-cued recall test. A common finding is that if some of the previously learned items are presented alongside the original category cues at retrieval, then recall of the remaining category members will be impaired. The impairment of the remaining category members compared to controls who only receive the category name as a cue is believed to be due to the operation of *part-set cueing inhibition*¹ (e.g., Mueller & Watkins, 1977; Roediger & Neely, 1982; Slamecka, 1968). Part-set cueing is an unusual interference effect as its occurrence is contrary to the expectation that presenting retrieval cues will aid the recall of the remaining category members.

Slamecka (1968) unexpectedly demonstrated part-set cueing in an episodic memory task where participants studied word lists composed of items from five semantic categories that were inter-mixed with each other. On the recall test, participants from the experimental condition received some of the category members as cues to help aid recall of the remaining category members, while participants in the control condition received all of the cues. Contrary to the assumption that the presentation of a category member at retrieval would act as a cue and facilitate recall for the remaining category members, participants who received cues recollected fewer remaining non-cued items than participants who did not receive any cues. Mueller and

¹ The use of the term 'inhibition' in part-set cueing does not imply the presence of an inhibitory mechanism, but rather, uses the term in a descriptive sense to infer an effect *opposite* to that of facilitation (R.A. Bjork, 1989). The use of the term 'inhibition' is discussed in greater detail later in this chapter.

Watkins (1977) later named this impairment 'part-set cueing inhibition' because utilising some category members as cues appeared to inhibit participant's recall of the remaining category members. This interpretation of the finding gained strength from various findings that the likelihood of recalling the remaining category members decreased as the number of cues presented for recall increased (Roediger, 1973; Rundus, 1973; Slamecka, 1968, 1972; Watkins, 1975). Thus, part-set cueing would seem to increase as the number of category members remaining to be recalled decreases.

Despite the apparent strength of the part-set cueing effect in recall memory, the effect disappears when recognition tests are used. Slamecka (1975) found no impairment when category members were used as cues in a forced-choice recognition test, regardless of the number of cues presented. Small part-set cueing effects on recognition tasks are typically only found when category exemplars that have not been used in the experiment appear on the forced-choice recognition task (Todres & Watkins, 1981). As recognition memory remains fairly unaffected, it would appear that target memories remain relatively intact, and it is the retrieval access of the desired memory that is impaired by part-set cueing.

Part-set Cueing as an Example of Interference in Episodic Memory

Unlike classical interference accounts of retrieval failures, part-set cueing considered the role that interference played in *episodic memory*. Tulving's (1972) original distinction between semantic and episodic memory systems occurred after interest in classical interference dwindled, and thus classical accounts of interference never considered the domains in which these effects occurred. In contrast, part-set cueing is classed as an interference effect that occurs in episodic memory primarily because it

can still be found when lists of items are used that do not share a semantic category (Slamecka, 1968). The part-set cueing effect has also been found to be independent of variables such as word frequency, rhyme and unrelated cues (the same as the paired-associated paradigms, Mueller & Watkins, 1977), and can occur simply because the items are presented within the same experimental episode (Roediger, Stellon & Tulving, 1977; Slamecka, 1968). Similarly, it has even been found to operate for category labels. Roediger (1978) found that participants who were presented with previously studied category labels were impaired in their recall of non-cued category labels in a free recall task. This intriguing result suggests that not only do the items within a category constitute a set, and thus are susceptible to part-set cueing inhibition, but the category labels also form a set that is subject to inhibition as well.

The Role of Competition in Part-set Cueing

Several theories have been proposed to account for the part-set cueing effect, but the most widely accepted, and influential on current theories of retrieval, is that advanced by Rundus (1973), and what Nickerson (1984) classifies as a '*competition at retrieval hypothesis*', which is based on the competition assumption and the strength-dependent assumption. This theory assumes that the presentation of category members as cues at recall results in the strengthening of the retrieval routes between that cue and its associated target. This strengthening of the association between the cue and its target will facilitate the retrieval availability of the target in comparison to the remaining non-cued items within that set. Thus, these stronger more accessible items are likely to block retrieval access of the remaining non-cued category members through part-set cueing.

The Strength-Dependent Assumption and Part-set Cueing

In terms of the strength-dependent assumption, and the competition assumption, part-set cueing predicts that the probability of a category member being retrieved is dependent on the strength of the association between a category label and its target member relative to the strength of that category label to all other competing category members. According to strength-dependent assumptions, strengthening the association between a cue and a specific item will raise the probability of that item being recalled on any subsequent retrieval attempt but decreases the probability of other items located at the same level in the hierarchy from being recalled on that subsequent attempt. This means that the association between the cue and competing items will be weakened through the strengthening of target associations, resulting in the competing items being subject to part-set cueing inhibition.

However, not all research is unilateral in its support of the strength-dependent assumption in part-set cueing as D.R. Basden, Basden & Galloway (1977) believe that it is the weakest assumption of Rundus' model. The strength-dependent assumption assumes that the probability of retrieving a non-cued member is dependent on its association to the category relative to the strength of association between the category and the rest of its members. This being so, D.R. Basden et al. predicted that the chances of recalling a weak target member from a category from the same level as other weak members should be the same as the probability of retrieving a strong target member from a field of strong members. In contrast, if a list of items is comprised of half strong members and half weak members, then the ratio rule predicts that more of the strong members should be recalled compared to a list composed exclusively of strong members. However, D.R. Basden et al.'s findings failed to support these predictions. Strong items from a mixed strong-weak list were not recalled in greater

numbers than strong items from a list composed of exclusively strong members, nor were weak items from a mixed list recalled poorer than items from a list composed only of weak items.

Despite D.R. Basden et al.'s results, the assumptions of part-set cueing are generally upheld by empirical data. In terms of the strength-dependent and competition assumption, increasing the number of cues at test will lead to a corresponding decrease in the number of remaining items recalled because an increasing number of competitors have been strengthened through their presentation as cues (Roediger, 1973; Slamecka, 1968, 1972; Watkins, 1975). As a result, part-set cueing should occur through the simple presentation of items from a category or set as cues as this, in itself, is sufficient to increase the strength of these items. Similarly, part-set cueing should be found irrespective of whether the category is semantic or episodic in nature (Mueller & Watkins, 1977; Roediger, Stellon & Tulving, 1977; Tulving, 1977; Slamecka, 1986), as well as occurring within the set of category cues employed at test (Roediger, 1978). Finally, part-set cueing should not be found under conditions where competition is absent, such as in recognition tests where the presentation of all items from the category or set resolves competition among items (Slamecka, 1975; Todres & Watkins, 1981).

Strength-Dependent Models and Inhibitory Accounts of Interference

Whether considered individually, or together, both the competition and strength-dependent assumptions contributed greatly to both classical and modern accounts of retrieval interference. Both of these assumptions have been combined into what M.C. Anderson and colleagues referred to as *strength-dependent competition models of interference* (M.C. Anderson & Bjork, 1994; M.C. Anderson et al., 1994), along with

a third assumption called the *retrieval-based learning assumption*. This third assumption states that the retrieval process in itself is a potent learning event and is sufficient to strengthen items in memory which, in turn, results in impaired recall of items that have not been strengthened through the retrieval process. However, there is a substantial body of research that suggests that the prior retrieval of information may not be a necessary condition for strengthening items in memory within strength-dependent competition models. For example, neither the SAM model (Mensink & Raaijmakers, 1988), nor part-set cueing (Rundus, 1973), which are both prime examples of strength-dependent competition models, require items to be strengthened through the retrieval process in order to produce interference effects. According to these models, merely allowing extra study time, or re-presenting target items, should be sufficient to strengthen these items and induce interference. The case for presenting items being sufficient to strengthen those items is particularly convincing in part-set cueing, given that the retrieval impairment is due to the *presentation* of a sub-set of items as cues at test.

Similarly, the pre-experimental strength of items that share a common cue is thought to be irrelevant to the strengthening process in strength-dependent competition models of interference. This is primarily because the critical factor in the strengthening of items in these models is the initial retrieval strength of the target and not the initial retrieval strength of the competing items. While strong targets will require less strengthening in order to interfere with the competing items, weak targets will require substantially more strengthening. In contrast, the initial strength of competing items will contribute little to this strengthening process, with weak competitors just as susceptible to impairment as competitors that are high in retrieval strength.

As it is the strengthening of the association between the target and the cue that interferes with the retrieval of competing items, this suggests that the focus of interference is along the retrieval route between the shared cue and the memory trace of the competing items. Thus, the impairment of these competing items can be reversed through resolving competition for access to the shared cue by simply changing the cues used for recall. More specifically, if recall of competing items is impaired through their use of the same retrieval cue as the strengthened target, then using a novel cue at retrieval should see the competing items being easily recalled.

Finally, these assumptions and predictions of strength-dependent competition models of interference strongly suggest that *non-inhibitory processes* underlie these forms of retrieval interference. The weakening of the associations between the cue and targets does not indicate the presence of any form of retrieval inhibition mechanism or mechanisms that resolves competition through the active suppression or inhibition of unwanted competing items. While inhibitory accounts of interference are in agreement with the assumption concerning the role of competition at retrieval, they differ in their interpretation of strength-dependent and retrieval-based learning assumptions. In contrast to non-inhibitory theories, inhibitory accounts assume that it is the initial strength of competing items that has the primary influence on the interference effect, rather than the focus being on the strength of the target item. Thus, inhibitory theories assume that strong competitors will require much more suppression or inhibition in order to prevent them interfering with the retrieval of the target items than will be required to inhibit weak competitors.

Inhibitory accounts of interference are also *retrieval specific*, with presentation or additional study being insufficient to trigger the inhibition of competing items. This is primarily due to inhibitory theories assuming that presenting competitors, or

allowing additional time to study those items, creates only minimal competition thereby negating any need to suppress those items. For example, supporters of inhibitory theories suggest that interference effects that are found through the presentation of items at recall (e.g., part-set cueing) are not the result of any kind of inhibitory process that reduces interference, but is actually due to a change in strategy from the study phase to that used during recall (D.R. Basden & Basden, 1995; Sloman, Bower & Roher, 1991).

Finally, as inhibitory accounts assume that the retrieval strength of competing items has been actively inhibited, they predict that these items will remain unavailable for retrieval even when retrieval cues are used that differ from those used during an episode of strengthening. This prediction differs from non-inhibitory theories as inhibitory accounts place the primary locus of impairment at the level of the memorial representations. If a memorial representation is truly inhibited, then it should be irrelevant whether the retrieval cue is novel or not, the end result is expected to be the same: the competing item remains impaired in memory.

Resolving Competition through Retrieval Inhibition

One of the first areas of interference research that saw the wide spread use of the term retrieval inhibition was that of *directed forgetting*. The directed forgetting effect, and the paradigm typically used to investigate this type of interference phenomenon, differs markedly from that used in classic and modern interference. While paired-associate and part-set cueing paradigms measured the effects of implicit cues to forget on subsequent memory performance, directed forgetting research employs explicit cues to forget. Thus, this makes directed forgetting a form of *motivated* or *intentional* forgetting that resembles real-life situations, whereby we wish intentionally to remove

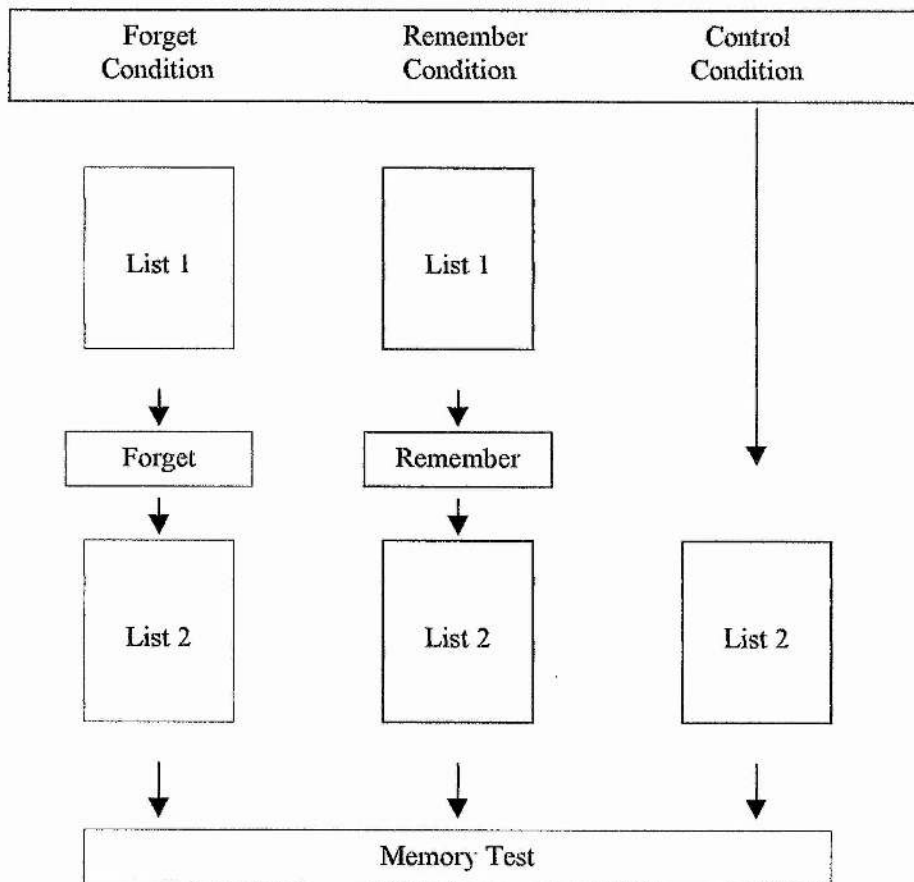
thoughts or memories from our conscious awareness. In this way, directed forgetting provides a technique for examining the deliberate updating of our own memories, and for examining the possible role that retrieval inhibition may play in this updating process.

The Directed Forgetting Paradigm

In a typical directed forgetting paradigm, participants are presented with a list of words to study for a later free recall test. However, half way through that list, some participants are asked to forget the previous items but to continue on and try and remember the following items, and these participants form the *forget condition*. These instructions to forget or remember certain parts of a list effectively divides the stimuli into two separate lists: the to-be-forgotten list and the to-be-remembered list. In contrast, other participants are not asked to forget the initial list and so have to try to remember all of the items from both of the lists. These participants form the *remember condition*. In addition, a control condition can be added where participants complete an unrelated filler task in place of the first list and then carry on and study the second list. This control condition can act as a baseline measure of recall for both the to-be-forgotten list and the to-be-remembered list. After all of the items on the final to-be-remembered list have been presented, participants are asked to recall items from either the to-be-remembered list only, the to-be-forgotten list only, or items from both lists, see Figure 5. Additionally, the directed forgetting paradigm can take the form of entire lists being presented before an instruction to remember or forget is issued, called the *list method*, or the remember or forget cue is presented after each individual word, typically called the *item*, or *item-by-item* method (see review by C.M. MacLeod, 1998).

Recall performance and the success of instructions to remember or forget can be measured in various ways. Directed forgetting can be measured by comparing the recall of to-be-remembered items to that of to-be-forgotten items within the forget condition. Directed forgetting can also be measured across conditions by comparing the recall performance for to-be-forgotten items with to-be-remembered items in the remember condition and in the control condition.

Figure 5: Directed forgetting paradigm



Note. Typical paradigm used in the directed forgetting paradigm using the list method

Typical Findings from the Directed Forgetting Paradigm

There are three typical findings that have been found across studies using the directed forgetting paradigm suggesting this method of intentional forgetting can produce robust effects. First of all, participants instructed to forget the initial list typically report more to-be-remembered items than participants who are instructed to remember both lists in the remember condition (e.g., E.L. Bjork & Bjork, 1996). This is due to recall in the remember condition being impaired through strong proactive interference effects. Thus, the successful forgetting of the initial list reduces, or even eliminates, the proactive interference that typically operates in the second list.

Second, participants asked to forget the first list recall the remember words from the second list equally as well as do participants in a control condition who have completed an unrelated filler task in place of the initial list. Primarily this is due to an absence or reduction in proactive interference during participant's recall of the to-be-remembered list in both of these conditions. Finally, recall for to-be-forgotten items is worse than for to-be-remembered words suggesting that participants have successfully followed instructions to disregard the first list (see C.M. MacLeod, 1998 for a full discussion on the basic directed forgetting effects).

Retrieval Inhibition as an Explanation of Directed Forgetting

While several accounts have been proposed to explain directed forgetting, including an erasure mechanism (Muther, 1965), and a segregation and selective rehearsal mechanism (R.A. Bjork, 1970), the retrieval inhibition account is favoured by many researchers as a convincing explanation of directed forgetting in the list method (e.g., R.A. Bjork, 1989; E.L. Bjork et al., 1998; E.L. Bjork et al., in press; Geiselman & Bagheri, 1985; Geiselman et al., 1983).

Instructing participants to forget a list that has just been presented is thought to trigger retrieval inhibition which, in turn, reduces retrieval access to those items. This loss of retrieval availability to the to-be-forgotten items prevents them from interfering with the retrieval of the new target items – the to-be-remembered items. As the to-be-forgotten items no longer interfere with the retrieval of the target items, proactive interference is eliminated, or at least significantly reduced. In contrast, participants who are not instructed to forget the initial list, and thus do not direct retrieval inhibition at these items, remain susceptible to proactive interference. As these participants are unable to inhibit items on the initial list, the items interfere with the retrieval of items from the second list. As a result, recall of items on the second list is typically impaired in comparison to participants who were instructed to forget the initial list.

List Method versus Item Method

Although some researchers have previously proposed that the retrieval inhibition may underlie both methods of producing directed forgetting effects (e.g., Geiselman & Bagheri, 1985; C.M. MacLeod, 1989), others have argued that the mechanisms that drive directed forgetting in the list method differ to those in the item method (B.H. Basden & Basden, 1996, 1998; B.H. Basden, Basden & Gargano, 1993). It has been suggested that each presentation method encourages different processing styles. While the item method may foster distinctive processing, the list method may encourage participants to encode and process the entire list using a relational processing style (Einstein & Hunt, 1981; Hunt & Einstein, 1980). With the item method, as each word is presented individually with remember or forget instructions, this may foster a unique and distinctive processing style that draws participant's

attention to the uniqueness of each item within the list. In contrast, the presentation of the remember or forget cue after the encoding of a list may encourage participants to process items within that list in relation to each other, as well as various contextual information, such as each item's temporal location within the list. Thus, retrieval inhibition would be more likely to act as a method of overcoming interference in the list method, where it could impair retrieval access to the list, rather than having to act on each individual item. Instead, a selective rehearsal mechanism has been proposed as the primary mechanism in the directed forgetting effect found with the item method (B.H. Basden & Basden, 1998; B.H. Basden et al., 1993). As such, only the list method, and retrieval inhibitions implied role in it, will be the basis of discussion (but see C.M. MacLeod et al., 2003, for recent discussion on directed forgetting using the list method also being due to differential encoding).

Retrieval Availability and Release from Inhibition

Despite the observed impairment in retrieving to-be-forgotten items, these items are not believed to be permanently lost from memory. Recognition memory for the to-be-forgotten items appears to be unaffected, that is items are recognised at the same level as to-be-forgotten items (e.g., R.A. Bjork, 1989; Block, 1971; Elmes, Adams & Roediger, 1970; Geiselman et al., 1983). If these items were permanently forgotten through the actions of an erasing process, then recognition memory should also have been impaired. Similarly, re-presentation of the to-be-forgotten items during an interpolated task resulted in the reinstatement of proactive interference in a subsequent recall task. In fact, presenting as few as four to-be-forgotten items can be sufficient to reinstate proactive interference to a similar level as that found in conditions where participants have to remember both lists (E.L. Bjork & Bjork, 1996).

While it could be argued that participants are merely re-encoding to-be-forgotten items that have been erased in memory through the instruction to forget, the fact that only a sub-set of to-be-forgotten items can reinstate proactive interference, rather than requiring the re-exposure of the complete list, suggests that this assumption is incorrect.

In terms of retrieval inhibition, the finding of intact recognition memory for to-be-forgotten items plus the reinstatement of proactive interference, suggests that re-exposure to even a minority of inhibited items is sufficient to result in the 'release' of retrieval inhibition. Thus, it would appear that retrieval inhibition is easily elicited and easily overcome. This would allow for a flexible updating process in memory that could quickly adapt to changing goal states. Finally, results from re-learning paradigms further add to the likelihood that the to-be-forgotten items are maintained in memory at full strength, but are only temporarily inaccessible (Geiselman & Bagheri, 1985). To-be-forgotten items are typically re-learned as quickly as to-be-recalled items, suggesting that despite having been inhibited, these items have equally as strong storage strength as to-be-forgotten items.

The Nature of Retrieval Inhibition: What Exactly is Inhibited?

While previous findings using recognition tests and re-learning paradigms suggest that to-be-forgotten items remain stored in memory and are not permanently forgotten, it does not tell us what form this inhibition takes. That is, does the to-be-forgotten list form a separate memory, is it retrieval access to this episodic memory that is inhibited, or are the memorial representations of each item in long-term memory actually inhibited? As directed forgetting is typically investigated using explicit memory tests that direct participants to recall information from the study

phase, these types of direct memory tests tell us very little about the nature of the inhibition. In contrast, implicit memory tests provide a way of investigating what level the inhibition operates at by bypassing any episodic memories formed from the study phase and directly accessing the stored memorial representations in long-term memory.

Implicit memory tests have been used in the list method as well as in the item method. While directed forgetting is sometimes found using the item method (e.g., B.H. Basden & Basden, 1996; C.M. MacLeod, 1989; Paller, 1990), impaired recall of to-be-forgotten items has never been found using implicit tests in the list method (e.g., B.H. Basden & Basden, 1996; E.L. Bjork & Bjork, 1996; Paller, 1990). This is despite several different tests being used, such as general knowledge (B.H. Basden & Basden, 1996; B.H. Basden et al., 1993), stem completion (Paller, 1990), and word fragment completion tasks (E.L. Bjork & Bjork, 1996). B.H. Basden and Basden (1998) have suggested that directed forgetting is not found in implicit tests using the list method because the to-be-remembered list and the to-be-forgotten lists are processed in a relational manner as two integrated units rather than as distinct and unique items. Thus, retrieval inhibition acts on the to-be-forgotten items, not as individual memorial representations, but as a whole list, suggesting that it may be more appropriate to refer to these items as a 'to-be-forgotten list'.

Therefore, the finding that directed forgetting in the list method only occurs on explicit tests would seem to suggest that the to-be-remembered list and the to-be-forgotten list are forming new and distinct episodic memories. Retrieval inhibition only appears to prevent participants gaining access to the episodic memory of the to-be-forgotten list by acting on an individual's newer episodic memories for information encoded during the experimental episode. As directed forgetting is not

found with implicit memory tests using the list method, it would suggest that retrieval inhibition does not inhibit memorial representations that are stored in long-term semantic memory.

Continuing Influences of Inhibited Items

Results from various studies appear to suggest that the to-be-forgotten list may be able to continue to influence thoughts and behaviours despite being inhibited. If only the to-be-forgotten items' retrieval strength is impaired by the actions of retrieval inhibition directed at those items, and to-be-forgotten items remain at full strength in memory, then these inhibited items may continue to influence behaviour in other ways.

While the use of recognition tests and re-learning paradigms would suggest that the to-be-forgotten items remain at full storage strength (e.g., R.A. Bjork & Bjork, 1992; Tulving & Pearlstone, 1966), despite their inhibited state, implicit tests suggest that it is only the episodic representation of the to-be-forgotten list that is inhibited, rather than individual memorial representations stored in long-term memory. This being so, it is entirely possible that the non-inhibited semantic representations of items from the to-be-forgotten list stored in long-term memory could continue to influence an individual's thought processes and behaviours. If inhibited memories do continue to influence our thoughts and behaviours, then this could have implications for situations where thoughts, memories, and actions need to be banished from conscious thought to prevent them from interfering with current goals, such as attempting to ignore obsessive or repetitive thoughts in clinical disorders, instructing juries to disregard evidence, attempting to ignore a mistake during an oral or practical examination, etc.

E.L. Bjork and Bjork (1996) examined this possibility by delaying a final recall task via an implicit memory test. After having demonstrated a directed forgetting effect in conditions where participants were instructed to forget specific lists, some participants then completed a word fragment test. This test should not require access to the materials learned during the study phase, and should instead require the retrieval of semantically stored material. After having completed this implicit memory test, participants completed a further recall task.

Consistent with previous research, a directed forgetting effect was not found with the intermediate implicit memory test. However, a directed forgetting effect was present in the delayed recall test that occurred after the word fragment completion task. This suggests that the recall task and the word fragment task were employing cues that accessed different types of memories, and because of this, the intermediate retrieval task did not release the inhibition of the to-be-forgotten list.

What is of interest, however, is that the prior presentation of the to-be-forgotten items in the study phase primed performance for those items in the word fragment task to the same degree as the to-be-remembered items (see also B.H. Basden et al., 1993). Participants completed more word fragments that referred to items presented during the study phase than for control items that were absent from this initial study phase. This further suggests that, not only may retrieval inhibition act on an episodic memory of the initial study phase rather than on long-term memorial representations, but also that the to-be-forgotten item's corresponding representation in semantic memory for the to-be-forgotten items can continue to guide and influence current memorial goals.

An instance where to-be-forgotten information has been successfully inhibited but continues to influence subsequent behaviours on indirect measures is that of jury

decision making following an instruction to disregard certain evidence. While mock juries appear to successfully inhibit disregarded evidence, they are more likely to find the defendant guilty than are control participants who did not receive biasing testimony (e.g., Caretta & Moreland, 1983; J.M. Golding, Fowler, Long & Latta, 1990). Similarly, in real jury trials, the more negative pre-trial publicity that a jury has been exposed to, the more likely they are to find the defendant guilty, despite the jury members continuing to claim impartiality (Constantini & King, 1980/1981; Moran & Cutler, 1991).

Output Interference: A Case of Interference in the Absence of Competition

Output interference provides an interesting exception to perhaps the most fundamental arguments of interference theory, that of the competition assumption. Output interference refers to the deleterious effects of the earlier retrieval of information on information that is retrieved later. For example, individuals who construct lists (e.g., lists of things to do, shopping lists) may find that it becomes more difficult to generate items after several examples have already been reported. If important items are missed from such a list then it is likely that they have been omitted due to output interference.

In a typical output interference paradigm, participants are presented with lists of items that belong to various categories, and after a brief retention interval, are cued to recall each item within each category. Items that are cued early within each category at test tend to be recalled better than items that are cued further down each category, and this output interference appears to be unaffected by the initial position of each category within the initial study list, as well as the position of each item within the initial study list (Roediger & Schmidt, 1980).

The retrieval process has been specifically implicated in output interference as the active retrieval of items from memory appears to be a necessary condition to induce impairment in memory. Simply presenting a category label with instructions to forget the category members appears to be insufficient to produce output interference (Roediger & Schmidt, 1980). This finding suggests that it is the very act of accessing information in memory during the retrieval process that leads to forgetting, an observation first made by Roediger earlier in 1974.

Not only does output interference suggest that the retrieval process in itself can create interference, but even more surprising is the finding that competition is not a necessary condition for output interference to occur. Rather than output interference being the result of the resolution of competition between a target and its competitors, it appears that output interference is simply the result of the prior retrieval of other information irrespective of whether these items share a common cue or not. For example, A.D. Smith (1971) had participants recall items from seven unrelated categories. As participants worked their way through the recall task from category one to category seven, output interference effects within each category increased. Recall of the first category was relatively high at 70%, but by the time participants reached the cued-recall of the final category, recall had dropped to only 45%. Similarly, Roediger & Schmidt (1980) also found a decline in memory performance within and across sets of unrelated paired-associates. Thus, even in the absence of competition for retrieval by a common cue, strong interference effects can still be found simply through the retrieval of items, and therefore provides a relatively 'pure' measure of the possible detrimental effects of the retrieval process.

Conclusions from Interference Theory

Studies of interference effects in episodic and semantic memory systems have highlighted and contributed several important findings to our understanding of the mechanisms governing interference effects in long-term memory, and continue to influence current theories. Decades of research into a variety of interference effects suggest that many causes of forgetting can be traced back to the effects of many items sharing a common cue. Under conditions where a single cue is associated to multiple targets, memory impairment is usually found. However, this is not always the case, and output interference has proven to be an interesting exception to the competition assumption. The strength-dependent assumption has also received much support from classical and modern interference research, suggesting that strengthening the association between a cue and a target may weaken the association between that shared cue and competing items.

However, recent research into modern interference effects, such as directed forgetting and output interference challenge some of these long held beliefs about the retrieval process. While output interference suggests that the retrieval process can be a direct cause of forgetting even in the absence of competition, directed forgetting can provide a model not only of intentional forgetting, but perhaps also the presence of an inhibitory retrieval process directed at unwanted competing items. Thus, retrieval inhibition may provide an alternative explanation to traditional strength-dependent competition models of interference.

CHAPTER 3

INHIBITORY PROCESSES IN RETRIEVAL-INDUCED FORGETTING

Research into intentional (e.g., directed forgetting) and unintentional forgetting (e.g., output interference, part-set cueing) has highlighted many interesting properties of memory, as well as greatly increasing our understanding of updating processes in memory. In the past, interference effects have primarily been explained by non-inhibitory theories, although more recently inhibitory processes in episodic memory have been inferred (i.e., retrieval inhibition in directed forgetting). Following on from the prior discussion of retrieval inhibition in intentional forgetting, the current chapter considers the evidence for inhibitory processes in unintentional forgetting, and specifically its role in retrieval-induced forgetting. As non-inhibitory theories can provide a more simplistic account of retrieval-induced forgetting, the case for inhibitory theories is examined through direct comparisons and tests of the assumptions and predictions of inhibitory versus non-inhibitory theories.

Retrieval as a Memory Modifier

The act of retrieval has long been perceived as a process far more complex than merely reading the contents of long-term memory; it has been assigned a more active status in controlling the information of which we are consciously aware. For example, an item can be strengthened in memory through its prior retrieval, thereby increasing the probability that it will be reported on a subsequent recall attempt. Thus, retrieval in itself can be a potent learning event (Allen et al., 1969; R.A. Bjork, 1975; R.A. Bjork & Bjork, 1992; Carrier & Pashler, 1992; Morris & Fritz, 2000,

2002), and typically, the greater the difficulty of this retrieval attempt, the greater the benefit for any future retrieval attempts (Landauer & Bjork, 1978).

Despite such positive consequences, recent research has indicated that retrieval can also have negative consequences for some memories, suggesting that the retrieval process itself may be a source of unintentional forgetting. For example, output interference appears to be the direct result of the earlier retrieval of items during a current retrieval attempt (e.g., Roediger, 1974; Roediger & Schmidt, 1980). Similarly, R.A. Bjork and Geiselman (1978) have observed both positive *and* negative consequences of retrieval within a single experiment. Using lists of word pairs in an item-by-item directed forgetting paradigm, the to-be-remembered items on each list were tested either immediately after presentation, or following a delay. At the conclusion of the experiment, all participants completed a free recall task of all items from both lists. Thus, some participants recalled all of the items only at the end of the experiment, or they retrieved the to-be-remembered items on an interpolated task before completing the final recall test.

The results indicated that participants who recalled the to-be-remembered items on an interpolated test recalled more to-be-remembered items on the final memory task than did participants who had not engaged in a prior period of selective retrieval. More interestingly, participants who had previously recalled the to-be-remembered items were poorer in their recall of the remaining to-be-forgotten items than were participants who never recalled any of the items during the retention interval. This finding of poorer recall for to-be-forgotten items after a period of selective retrieval is quite surprising given that the to-be-forgotten items have been treated in the same way in both conditions (i.e., they have been presented the same number of times and have been subject to the same directed forgetting instructions).

Thus, retrieval can modify memory by strengthening some items, by increasing the likelihood of their subsequent retrieval, while simultaneously reducing the retrievability of other items. R.A Bjork and Geiselman's study also demonstrates that forgetting may not only be the result of intentional attempts to disregard information, but also unintentional effects of the retrieval process itself.

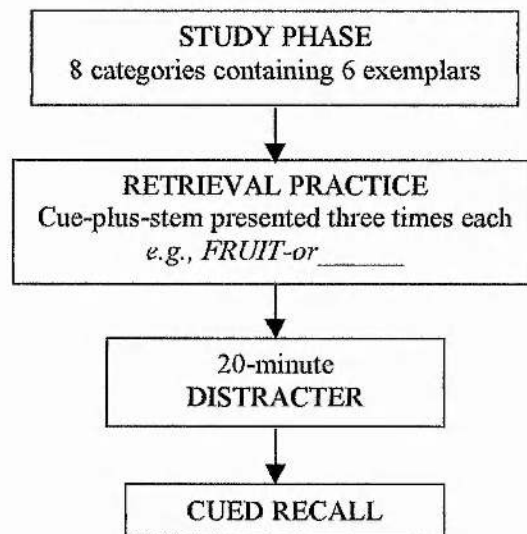
Retrieval-induced Forgetting

While output interference suggests that unintentional forgetting can occur during the recall process, can the positive and negative consequences of an earlier retrieval attempt, as implied by R.A Bjork and Geiselman (1978), also be present during a later retrieval attempt without a direct instruction to forget? M.C. Anderson et al. (1994) set about examining these possibilities using a novel paradigm, called the *retrieval practice* paradigm, that allowed them to measure the effects of an earlier retrieval attempt on subsequent retrieval.

This retrieval practice paradigm typically contains four phases: a study phase; a retrieval practice phase; a distracter; and a final recall task. In the study phase participants are presented with lists of categories containing related items, for example, in Anderson et al. (1994), there are eight categories containing six exemplars in each, such as the category FRUIT, and the exemplars APPLE, ORANGE, BANANA, etc. After studying these lists, participants engage in a retrieval practice task, such as presenting the category cue FRUIT and the exemplar stem AP____. This retrieval practice task requires participants to access items from selective categories (practiced categories), while ignoring others (unpracticed categories). Participants are required to retrieve repeatedly half of the exemplars from half of the categories (for example, retrieve APPLE three times). This task creates

three distinct types of items: practiced items from the practiced category (RP+ items); unpracticed items from the practiced category (RP- items); and unpracticed categories, where no exemplars have been practiced (NRP items), see Figure 6

Figure 6: Retrieval practice paradigm



In line with other memory tasks, recall of the practiced RP+ items was significantly higher than that of the unpracticed NRP category (e.g., Allen et al., 1969; Carrier & Pashler, 1992). Enhanced recall of RP+ items confirms that the act of retrieval is a potent learning event that strengthens the trace in memory. However, this paradigm also gives rise to findings that are contrary to facilitatory priming effects (e.g., Neely, 1976, 1977), and spreading activation models (J.R. Anderson, 1983; Freedman & Loftus, 1971; E.F. Loftus, 1973; G.R. Loftus & Loftus, 1974; Roediger & McDermott, 1995). Specifically, the recall of RP- items from the practiced category tends to be poorer than for NRP recall despite both item types being treated identically (i.e., participants studied both items only once, and for the

same duration, during the study phase). The impairment in the retrieval of non-practiced RP- items relative to the NRP baseline is typically referred to as *retrieval-induced forgetting*.

Resolving Competition in the Retrieval Practice Paradigm through Non-inhibitory and Inhibitory Processes

What kind of processes might be responsible for the impaired recall of RP- items? Perhaps the most parsimonious account of retrieval-induced forgetting is that proposed by non-inhibitory theories that require fewer steps to explain the impaired RP- performance than other more complex inhibitory theories. More specifically, this basic retrieval-induced forgetting effect can be accommodated by the competition and cue-specific assumptions of non-inhibitory theories. For example, non-inhibitory theories predict that retrieval-induced forgetting will be a cue-specific effect, and thus only non-retrieved items that share a common cue with the target items should be subject to impaired retrieval. Similarly, these theories also predict that items that share a common cue will compete for retrieval. When a sub-set of these items are strengthened through the retrieval process the association between the shared cue and the remaining non-retrieved items should be weakened. These predictions were both supported, with only the RP- items, which share a common cue with the target items and thus compete for retrieval with them, being impaired (M.C. Anderson et al., 1994). In contrast, the recall of items from the unpracticed categories, which do not share a retrieval cue with the target items and therefore do not compete for retrieval with the RP+ items, remain unaffected.

Retrieval-induced forgetting, however, can also be accounted for by inhibitory theories that encompass the general assumptions previously described for non-

inhibitory theories. That is, inhibitory theories predict that competition for retrieval is resolved through the actions of inhibitory processes directed at competing items. In the case of the retrieval practice paradigm, presenting the retrieval practice cue is thought to result in all items associated with that cue competing for retrieval. In order to prevent unwanted competitors creating interference and disrupting the retrieval of RP+ items, inhibitory processes are brought to bear on the RP- items.

However, as R.A. Bjork (1989) has previously highlighted, what form would this inhibitory process take? In its "most theoretically neutral sense" (M.C. Anderson & Bjork, 1994, p. 267), the term 'inhibition' has been used to describe an effect that would not have occurred in the absence of the independent variable (see also C.M. MacLeod et al., 2003). Similarly, a weak descriptive interpretation of inhibition makes no theoretical assumptions concerning memory traces, and merely describes an empirical finding that is the opposite of facilitation. In contrast, the strongest interpretation goes beyond describing an empirical effect and asserts the presence of an inhibitory mechanism that acts on the memorial representation to actively reduce its level of activation. But does retrieval-induced forgetting qualify as the effect of a true inhibitory mechanism, or is it merely the description of an empirical effect?

Inferring Inhibitory Processes

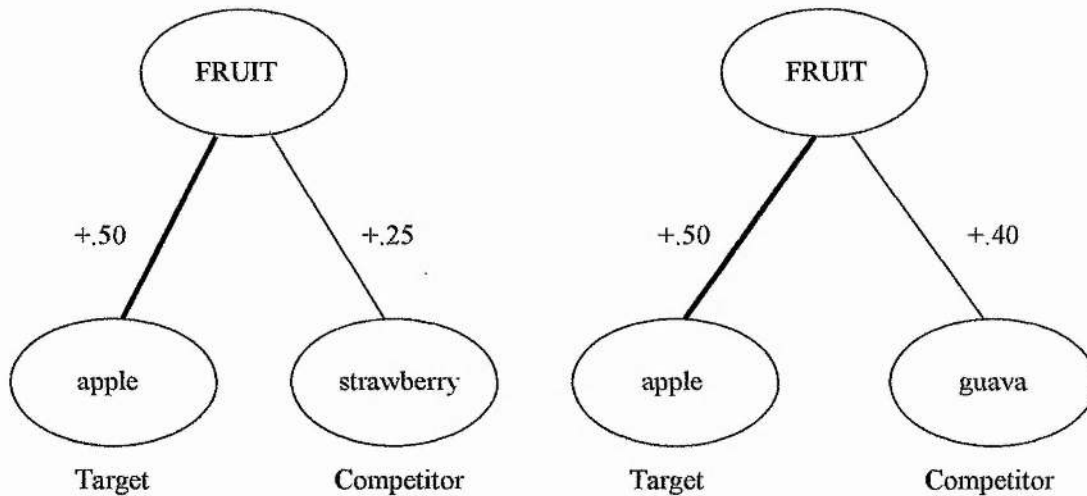
Inhibitory processes have previously been advanced as an explanation for the directed forgetting effect in episodic memory, but can examples of retrieval inhibition only be found in motivated forgetting, or can it also be inferred in more common cases of unintentional forgetting? Given that non-inhibitory processes can provide a more parsimonious account of the basic retrieval-induced forgetting effect (see M.C. Anderson & Bjork, 1994; M.C. Anderson & Neely, 1996; M.C. Anderson &

Spellman, 1995, for further discussion), retrieval inhibition can only be inferred if non-inhibitory theories fail to provide a complete and adequate account of these retrieval failures. Despite this, non-inhibitory theories may not always be the more appropriate explanation of retrieval-induced forgetting. One of the primary predictions of non-inhibitory theories concerns the effects of strengthening the association between a cue and its target on other items that are also associated with that cue. While non-inhibitory theories assume that interference is a direct effect of the act of strengthening a target's association with its cue, inhibitory theories assume that the probability of interference occurring is more dependent on the initial strength of competing items rather than the strengthening of the target.

In an effort to test this hypothesis more vigorously concerning the underlying processes of retrieval-induced forgetting, M.C. Anderson et al. (1994) manipulated the taxonomic strength of items within the RP+, RP-, and NRP sub-sets, i.e., the RP+ sub-set could consist of exclusively strong or weak category members; the RP- set could consist entirely of strong or weak items; and half of the NRP set could be composed of strong items with the remaining items being only weakly associated to the cue. As inhibitory theories assume that varying the strength of the RP- items will affect the magnitude of retrieval-induced forgetting, interference is likely only to be found when the RP- item is of strong taxonomic strength, see Figure 7.

Non-inhibitory theories, in contrast, assume that it is the strength of the RP+ item that impairs recall of competing items, and so retrieval-induced forgetting should be found irrespective of the strength of the RP- items, see Figure 8. Following this line of argument, retrieval-induced forgetting should be found in any condition where practice effects are demonstrated, indicating that the RP+ items have been sufficiently strengthened.

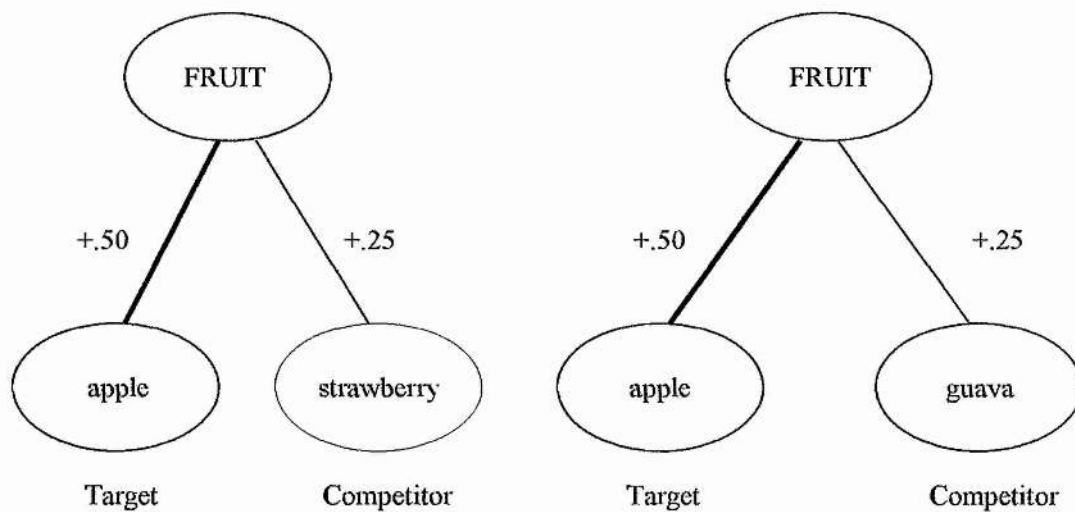
Figure 7: The role of initial exemplar strength in inhibitory theories



Note. Targets in both exemplars are strengthened to the same degree, however, 'strawberry' is more strongly associated with the cue 'FRUIT' than 'guava' is. Thus, 'strawberry' is a stronger competitor and is likely to create more interference than 'guava'. As such, in order to resolve this competition, 'strawberry' is subject to a greater degree of inhibition than 'guava'.

M.C. Anderson et al. (1994), however, found that varying the strength of the RP- items was the best predictor of retrieval-induced forgetting, with robust impairment found when the RP- items were of a strong taxonomic strength. In contrast, retrieval-induced forgetting was entirely absent when the RP- items were only weakly associated to the cue. Recall of the RP- items actually benefited from sharing a cue with the practiced items. Inhibitory theories explain this variation in retrieval-induced forgetting through the assumption that strong RP- items are in a stronger position than weak RP- items to compete for retrieval with RP+ items. As stronger competitors, these RP- items are likely to create more interference during retrieval of RP+ items.

Figure 8: The role of initial exemplar strength in non-inhibitory theories



Note. Targets in both examples are strengthened to the same degree, and so the strength-dependent assumption would predict that both 'strawberry' and 'guava' should be impaired to the same degree by the retrieval practice of the target 'apple'.

Thus, here is an example of non-inhibitory theories being unable to account for the selective interference of strong RP- items in the retrieval-induced forgetting effect. Thus, the actions of an additional inhibitory mechanism may be inferred as a possible solution for these findings. An inhibitory account of retrieval-induced forgetting assumes that the presentation of the category cue during retrieval practice leads to all category members vying for retrieval access. This means that, in addition to the target item preparing itself for retrieval, all related but unwanted items also compete for retrieval access with the target item. In addition, the stronger the association between the competing item and its cue the more severe the interference will be. If these related but unwanted items remain at a high level of retrieval strength, then they will create interference at the retrieval stage leading to the slow

retrieval of the desired item, or at the extreme, retrieval failure. In order to prevent such inefficient retrieval, a suppression/inhibition process would actively reduce accessibility to memorial representations of any competing items, preventing them from interfering with the retrieval of target items. As such, the use of the term suppression or inhibition is used in its strongest sense to infer the actions of an inhibitory mechanism (M.C. Anderson & Neely, 1996; M.C. Anderson & Spellman, 1995; R.A. Bjork, 1989). Following on from this, it is assumed that the stronger the item the greater the interference that could potentially be created. In contrast, the weaker the item the weaker the interference. Therefore, stronger items are subject to greater inhibition or suppression through the actions of an inhibitory mechanism than are weaker items.

Bäuml (1998) found similar support for this inhibitory account of strength-dependent *competitor* (rather than the strength-dependent competition assumed by non-inhibitory theories) impairment using an output interference paradigm. Participants studied lists containing categories composed of either moderate and strong category members, or of moderate and weak category members and were subsequently prompted to recall either the moderate category members before the strong members, or the moderate category members before the weak members. In line with inhibitory theories, the prior recall of moderate items impaired the later recall of strong items to a much greater degree than it impaired weak items. As these strong category members create more interference during the retrieval of the moderate strength members, the strong items will be subject to greater inhibition in order to reduce this interference. In contrast, as weak members are unlikely to compete for retrieval with moderate items, they will create little interference and thus be subject to little, if any, inhibition.

In a similar study, Bäuml, Kissler and Rak (2002) investigated the role of exemplar strength in part-set cueing effects in healthy control participants and patients suffering from amnesia caused by various brain traumas. Amnesic patients were used because individuals suffering from this syndrome typically display intact short-term and semantic memory, but also typically suffer from deficits in recalling recently encoded episodic information (Baddeley, 1997). Using the same moderate/strong and moderate/weak lists, the part-set cueing of moderate category members was found to impair the recall of strong members, but not the recall of weak members in the healthy population. In contrast, the amnesic patients demonstrated part-set cueing effects from both strong and weak items, suggesting that this population may suffer from more general retrieval impairments than healthy populations. In addition, as amnesics usually demonstrate intact retroactive and proactive interference (Isaac & Mayes, 1999; Warrington & Weiskrantz, 1978), the presence of strong part-set cueing effects in Bäuml et al.'s study suggests that the type of interference seen in part-set cueing may be mediated by different mechanisms to that typically attributed to retroactive and proactive interference. This raises the, as yet, unaddressed question of whether the mechanisms underlying retrieval-induced forgetting and part-set cueing are, in fact, the same.

In contrast, Williams and Zacks (2001) failed to find a distinction between strong and weak competitors using 'similar' materials to M.C. Anderson et al. (1994), with weak RP- items giving rise to similar retrieval-induced forgetting effects as strong RP- items. Williams and Zacks suggest that their data support the presence of non-inhibitory processes and further propose that retrieval-induced forgetting is actually a product of output order during final recall rather than inhibitory processes. Unfortunately, their claim is not without some difficulties. For example, the average

rank score of the materials used, according to Battig and Montague (1969), was 7.5 for the strong exemplars (eliciting a retrieval-induced forgetting effect of -6.95), and 32.4 for the weak exemplars (eliciting a retrieval-induced forgetting effect of -6.4). When average rank scores, and size of retrieval-induced forgetting effects in M.C. Anderson et al. (1994) are considered alongside that of Williams and Zacks their results actually fall in line with M.C. Anderson et al.'s inhibitory interpretation. In M.C. Anderson et al. (1994), the first two studies used exemplars of similar strength (average rank order of 8 for strong exemplars, and 33 for weak exemplars) to that employed by Williams and Zacks. M.C. Anderson et al. found a reduced retrieval-induced forgetting effect for weak exemplars of -6.3% (compared to -15.7% for strong competitors) in the first experiment, but the results were confounded by output interference, and no difference in the second experiment ($+0.2\%$, compared to -8.0 for strong competitors) when output interference effects were controlled for. However, in a subsequent experiment, where the taxonomic strength of the RP- items was weakened further ($M = 50$), M.C. Anderson et al. discovered that these extremely weak RP- items actually benefited from sharing a retrieval cue with the RP+ items (RP- recall = $+8.8\%$). Thus, it is possible that if Williams and Zacks had used even weaker exemplars, they may also have found that weak RP- items benefited from sharing a category with the practiced items.

Williams and Zacks belief that retrieval-induced forgetting is the result of interference acting at retrieval, rather than inhibitory processes elicited during retrieval practice, is also not without difficulties. While output interference has previously been found to influence recall in the retrieval practice paradigm (M.C. Anderson et al., 1994; Shaw et al., 1995), Williams and Zacks only assume that output interference is operating during final recall. That is, they neither controlled for, nor

demonstrated through post-hoc statistical analysis, that output interference was influencing recall.

The Role of Retrieval in Inhibitory Theories of Interference

Inhibitory and non-inhibitory theories also differ in their assumptions and predictions concerning how the strengthening of RP+ items is achieved. The strength-dependent assumption of non-inhibitory theories is relatively non-specific, suggesting that RP-performance can be impaired by strengthening the target item through its retrieval, *or* through additional presentations of those target items, *or* extra study time, implying that retrieval may not be a necessary condition in the production of retrieval-induced forgetting. In contrast, inhibitory theories assume that retrieval-induced forgetting is a retrieval-specific interference effect that is elicited through the active retrieval of a sub-set of items. In support of this retrieval-specific assumption, simply re-exposing target materials has been found to be insufficient to impair recall of competing item (M.C. Anderson, Bjork & Bjork, 2000a). For example, Blaxton and Neely (1983) found that participants were slower to retrieve a member of a semantic category after having previously retrieved other members of that same category. On the other hand, participants were faster to retrieve a target category member if they had previously been re-exposed to other category members.

Similarly, Bäuml (1996) investigated the effects of studying word lists during the retention interval between initial encoding of target material and their final retrieval on the retroactive interference effect. Exposure to the intervening word lists was manipulated from low exposure (2 seconds to view each item) to high exposure (5 seconds per item). Following the final list, memory for the target material from the initial list was tested first, followed by recall of the additional intervening lists. While

ability to recall the items from the intervening lists was found to be significantly better in the high exposure group compared to the low exposure group, there was no increase in retroactive interference between the two groups. Thus, these two studies suggest that, not only is strengthening an item through additional study trials insufficient to create impairment, but that retrieval is a necessary process to impair related information.

These findings of retrieval-specific interference may indicate that retrieval-induced forgetting could also be a retrieval-specific process. M.C. Anderson et al. (2000a) investigated this possibility using the retrieval practice paradigm. Recall performance from a condition where participants performed active retrieval practice (e.g., FRUIT-or____) was compared with another condition where participants were re-presented with the target item and retrieved its category cue instead (e.g., FR____-orange). According to inhibitory theories, retrieval-induced forgetting should only be found in the retrieval practice condition, as presentation of the retrieval practice cue should encourage RP- items to compete for retrieval, resulting in these items being suppressed in order to reduce interference. However, while re-presenting the RP+ items strengthening them, it does not create competition and thus interference is unlikely to occur at retrieval. On the other hand, non-inhibitory theories predict that strengthening an item through re-presentation is sufficient to create interference and impair the recall of RP- items. Therefore, while participants in both of these conditions must complete a retrieval task, only the retrieval practice task requires the active and specific retrieval of target item, and thus is the only condition that creates competition.

The findings of M.C. Anderson et al. (2000a) support an inhibitory account for the observed memory performance. Impaired recall of RP- items was only found in

the standard retrieval practice condition where target items were subject to retrieval practice. Not only was RP- performance not depressed in the re-exposure condition, but the recall performance of these items actually benefited from the re-presentation of fellow category members. Similarly, Ciranni and Shimamura (1999) and Bäuml (2002) found that simply re-presenting RP+ items was insufficient to elicit retrieval-induced forgetting. RP+ items had to be actively retrieved in order to produce RP- impairment. Non-inhibitory theories are unable to account for these failures to produce impairment through the strengthening of RP+ items without their active retrieval.

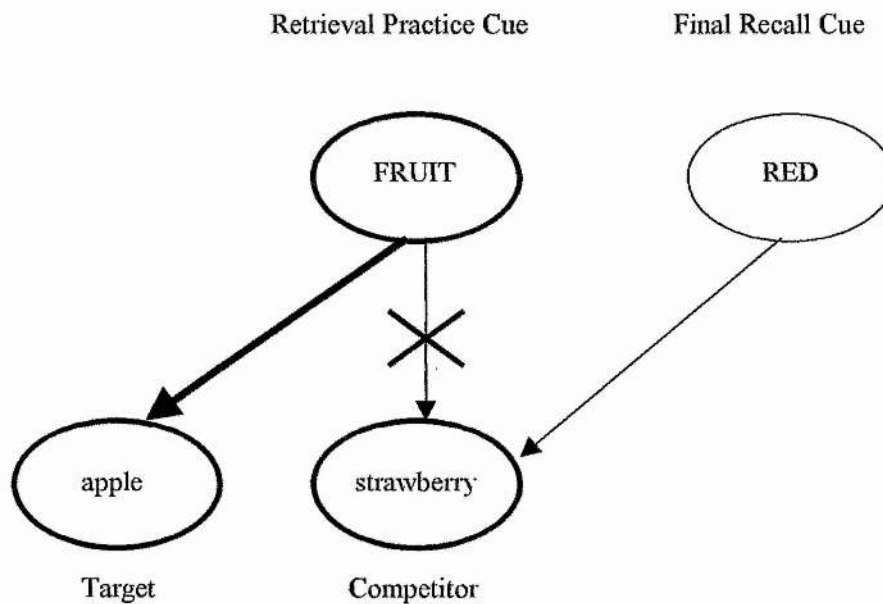
The retrieval-specific nature of retrieval-induced forgetting is not just a result of retrieving information from episodic memory, but also generalises to retrieving items from long-term semantic memory as well. Bäuml (2002) found that retrieval-induced forgetting could be elicited through the semantic generation of RP+ items that had not previously been presented at any point during the experiment. Thus, the target RP+ items were not drawn from the same episode as that of the RP- items, and instead were generated from long-term memory. This suggests that not only do target items and their competitors not have to come from the same episode in order to elicit retrieval-induced forgetting, but retrieving information from long-term memory can also produce the same effect.

Cue-independent Forgetting in Inhibitory Theories

Thus far, non-inhibitory theories have been unable to fully account for the failure to find retrieval-induced forgetting where RP+ items are strengthened through non-competitive retrieval conditions, or where competitors were only weakly associated to a common cue. However, the failure of non-inhibitory theories to fully account for

retrieval-induced forgetting is further compounded by the finding that this form of retrieval interference is also a *cue-independent forgetting* effect (e.g., M.C. Anderson & Green, 2001; M.C. Anderson, Green & McCulloch, 2000b; Levy & M.C. Anderson, 2002; M.C. Anderson & Spellman, 1995). Currently, this is perhaps the strongest and most convincing evidence for the presence of inhibitory processes (M.C. Anderson & Bjork, 1994; M.C. Anderson & Spellman, 1995). The notion that competitors can remain inhibited even when a different retrieval cue is used is strong evidence against the primary assumption of *cue-dependent forgetting* in non-inhibitory theories. This assumption is a direct result of how non-inhibitory theories organise information in memory and how they conceive the retrieval process. Thus, multiple memories are assumed to be associated to a single cue, and increasing the number of items accessed by a cue is likely to lead to a corresponding increase in competition, and thus interference. As it is the sharing of a common cue (i.e., the non-specificity of retrieval cues) that triggers retrieval-induced forgetting, non-inhibitory theories predict that retrieval impairment is a cue-dependent phenomenon. Strengthening the association between a cue and its target weakens the association between competitors and that shared cue, resulting in impaired retrieval of those competitors, see Figure 9. However, the interference from competitors can be overcome by simply using a new retrieval cue that is not shared by the target. Thus, non-inhibitory theories assume that retrieval-induced forgetting is due to interference occurring along the retrieval route between cue and competitor.

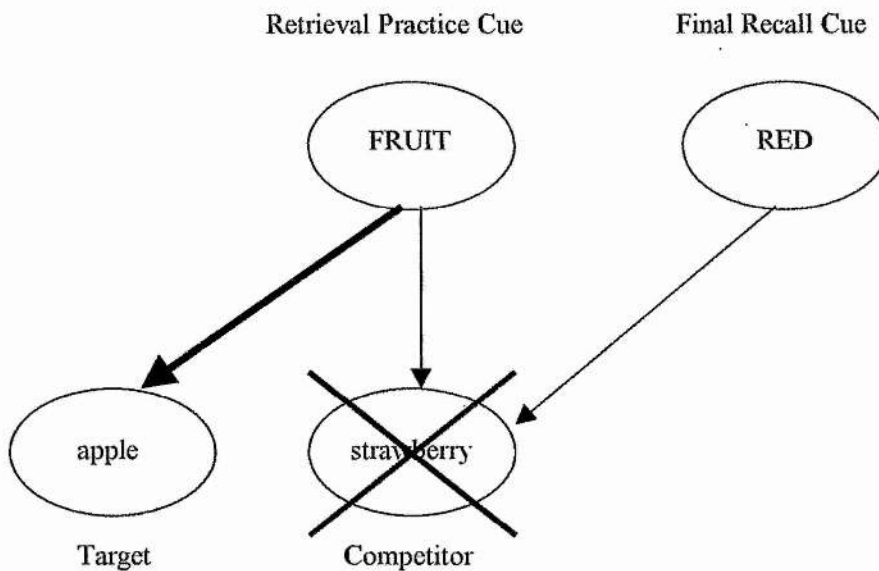
Figure 9: Cue-dependent forgetting



Note. As non-inhibitory theories assume that RP- items are impaired due to interference occurring along the retrieval route between FRUIT-strawberry, RP- items can be retrieved when a new retrieval route is employed that is free from interference (e.g., RED).

In contrast, inhibitory theories assume that retrieval-induced forgetting can also be cue-independent. As the level of activation of the memorial representations of competing items may be reduced by inhibition, the number of items associated with a common cue is less critical to inhibitory theories. As such, retrieval-induced forgetting should still be found when a new retrieval cue is used that differs from the one used to strengthen the association between the target and its cue, see Figure 10.

Figure 10: Cue-independent forgetting

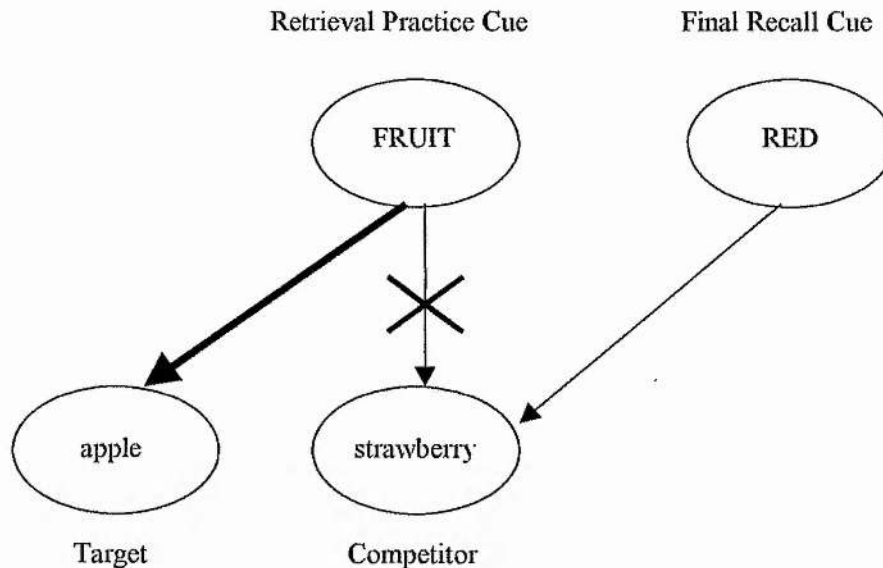


Note. As inhibitory theories assume that the memorial representation of the RP- item has been inhibited in long-term memory, this item should remain unavailable for retrieval even when a novel cue is used during final recall.

M.C. Anderson and Spellman (1995) used this distinction between cue-independent and cue-dependent forgetting effects to design a novel testing procedure for determining whether memorial representations are suppressed or not. The *independent probe method* employs retrieval cues at test that differ from those used during retrieval practice to strengthen the association between the RP+ items and their cue. By using novel retrieval cues, any interference occurring along the retrieval route between the cue and the RP- item is bypassed, see Figure 11. Therefore, if RP- items are recalled, then it suggests that non-inhibitory processes primarily underlie retrieval-induced forgetting, and further implies that memorial representations in long-term memory remain unaffected. In contrast, if recall of the RP- items remains

impaired then it suggests that the memorial representations of those items may actually be suppressed in long-term memory.

Figure 11: Independent probe method (M.C. Anderson & Spellman, 1995)



Note. The independent probe method requires recall cues to be used that differ from those used during retrieval practice. While presentation of 'FRUIT-ap_____' during retrieval practice strengthens the relationship between cue and target, it also results in the weakening the association between 'FRUIT-st_____', either through inhibitory or non-inhibitory processes. However, as inhibitory theories assume that the memorial representation of the RP- item has been inhibited in long-term memory, this item should remain unavailable for retrieval even when a novel cue has been employed during final recall. In contrast, as non-inhibitory theories assume that RP- items are impaired due to interference occurring along the retrieval route between 'FRUIT-strawberry', the RP- item can be retrieved when a new retrieval route is employed that is free from interference (e.g., 'RED').

M.C. Anderson and Spellman (1995) uncovered two major findings using this independent probe method that are consistent with an inhibitory account. First, and most importantly, retrieval-induced forgetting was still present even when these novel cues were used at recall (M.C. Anderson & Green, 2001; M.C. Anderson et al.,

2000b; Ciranni & Shimamura, 1999). That forgetting occurs independently of the type of retrieval cues employed at recall, suggests the presence of an inhibitory mechanism that acts on competitors to suppress their memorial representations. It also has a number of interesting implications for retrieval techniques that have previously been based on cue-dependent forgetting (e.g., cognitive interview, Bekerian & Dennett, 1993; Fisher & Geiselman, 1988; Geiselman, Fisher, MacKinnon & Holland, 1985).

More recently, cue-independent forgetting has been demonstrated in a different paradigm called the Think/No-Think task. M.C. Anderson and Green (2001) adapted the Go/No-Go task, a form of stop signal task, which is typically employed in neuropsychological research and requires participants to withhold a motor action in response to an external signal. However, the Think/No-Think task goes beyond requiring participants to try and withhold a pre-potent response and attempts to encourage participants to try and prevent specific information from entering conscious awareness. Participants attempt this by exerting control over these unwanted memories and intentionally suppressing them.

Not only were participants less likely to recall these suppressed items in a subsequent test compared to items that had neither been previously retrieved or suppressed (see also Hertel & Gerstle, in press), but unwanted items remained suppressed even when novel cues were employed at recall. M.C. Anderson and Green (2001) suggested that unwanted information is suppressed through the recruitment of executive control processes, thus going one step further than M.C. Anderson and Spellman (1995) and directly inferring the actions of inhibitory neurons in controlling the conscious awareness of memories. By suppressing unwanted information in this manner, an individual can ensure that the unwanted information never reaches

conscious awareness. Thus, not only can inhibitory processes be ascribed to the unconscious forgetting of competing information at the level of the memorial representations (i.e., retrieval-induced forgetting), but also to the conscious and deliberate suppression of unwanted memories.

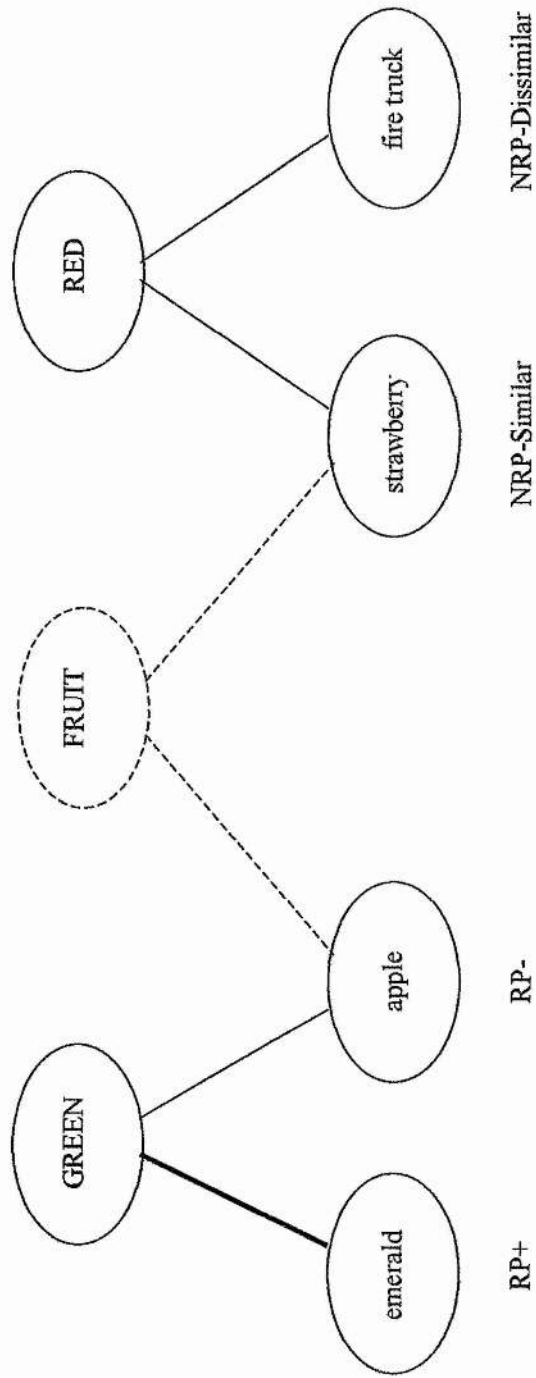
Beyond the work of M.C. Anderson lab, only one other laboratory has provided corroborating evidence for cue-independent forgetting. In a study by Ciranni and Shimamura (1999), the type of retrieval cue used at final recall was manipulated using visuo-spatial materials. In a typical condition, the cues used during the recall stage matched those used during the retrieval practice phase. As expected, retrieval-induced forgetting was found, but as the cues used during retrieval practice were also used during the recall stage, non-inhibitory theories cannot be discounted as a possible explanation. In one study, however, the cues used during final recall were the same ones as those under which the stimuli were originally encoded. This means with which the cues that the RP+ items have become strongly associated during retrieval practice were not used during final recall, and thus the design of this study may constitute a more simplistic form of the independent probe method. As retrieval-induced forgetting was still found when these non-retrieval practice cues were used at recall, it implies that RP- items themselves have been inhibited rather than retrieval access being blocked through non-inhibitory means.

The second major finding of M.C. Anderson and Spellman (1995) was that of *cross-category* impairment. Not only did the independent probe method determine that RP- items were inhibited, but also any items from the unpracticed category that were semantically similar to items from the practiced category (called *NRP-Similar items*) were also found to have been suppressed. A particularly compelling case of cross-category impairment is *second-order inhibition*, where NRP-Similar items are

inhibited due to their similarity with the RP- items, see Figure 12. While inhibitory theories predict that NRP-Similar performance would be impaired if some of the NRP items shared a related category with RP+ items, it does not seem instantly obvious as to why NRP-Similar items should also be inhibited if they are semantically similar to RP- items. Similarly, non-inhibitory theories cannot explain second-order impairment, as the RP+ items do not share a common cue with the NRP-Similar items, and thus the NRP-Similar items should remain unimpaired. In contrast, inhibitory theories can explain second-order inhibition, although they are not a primary prediction of inhibitory theories (see M.C. Anderson & Spellman, 1995, for further discussion). For example, inhibitory theories may be able to explain second-order inhibition by assuming that inhibition 'leaks' from the inhibited RP- items to any related items, thus making NRP-Similar items act like a second RP- group.

The likelihood of this unusual finding being the result of inhibitory processes gains credibility through the additional experimentation that M.C. Anderson and Spellman undertook to ensure that non-inhibitory theories could not explain these results. For example, second-order inhibition, as well as the inhibition of RP- items, may be explained by the cue-overload principle (Watkins, 1975, 1978). This was a possibility due to the RP- items also belonging to the same implicit category as some of the NRP items and so more items were associated with a single cue compared to a control condition where the RP- items did not share a related category with some of the NRP items. However, second-order inhibitory effects were found to be dependent on both the prior retrieval of RP+ items and the shared similarity between NRP and RP- items. The absence of second-order inhibition when participants performed retrieval practice on unrelated filler categories instead of on target items indicates that cue-

Figure 12: Second-order inhibition in retrieval-induced forgetting



Note. Items from the unpracticed category that are similar to inhibited items from the practiced category are also susceptible to inhibition. This is thought to be due to inhibition 'leaking' from the inhibited items to the NRP-Similar items.

overload cannot account for second-order inhibition. As this condition was the same as in the retrieval practice condition (i.e., that there was the same number of RP- items sharing a related category with NRP items), it would suggest that the increased number of items sharing a retrieval cue in the conditions that contain related categories is not a cause of second-order inhibition. Further to this, NRP performance was unimpaired by the prior retrieval of RP+ items if none of the NRP items shared a related category with any of the items from the practiced category.

Retrieval-induced forgetting in Recognition Tests: The Continuing Persistence of Inhibition

Recognition tests have been repeatedly used in interference research due to their alleged ability to resolve retrieval competition through presenting both targets and competitors at test (Ratcliffe, Clark & Shiffrin, 1990), and provide another avenue of exploring for the inhibitory account of retrieval-induced forgetting. Non-inhibitory theories predict that re-presenting RP- items on a recognition test should remove the effects of competition, and thus predict that retrieval-induced forgetting will not be found. In contrast, inhibitory models predict that the memorial representation of the RP- items will be inhibited and remain unavailable to conscious inspection. Thus, even when the RP- items are re-presented, if these items are truly inhibited, then recognition of RP- items will remain impaired (but see concluding paragraph of this sub-section).

In support of inhibitory theories, Hicks and Starns (in press) found significant retrieval-induced forgetting effects on recognition tests, but even more interestingly, participants were also more likely to claim that the RP- items were new items (i.e., had not appeared on the initial study list) than they were to make the same claim for

NRP items. This is quite a startling result, given that participants were exposed to both the NRP and RP- items only once. This pattern of results suggests that the memorial representation of RP- items may be inhibited in memory and unavailable to conscious inspection. However, while these results are consistent with an inhibitory account of retrieval-induced forgetting, Hicks and Starns dismissal of non-inhibitory theories would have been strengthened with the inclusion of a control condition. If retrieval-induced forgetting was absent at recognition after participants had performed additional study trials, this would have significantly strengthened Hicks and Starns interpretation of their results, especially as Koutstaal, Schacter, Johnson and Galluccio (1999) failed to find the effect for actions in a recognition test (although this may be the result of actions being more richly encoded than the study lists used in Hicks & Starns, in press). Despite this, retrieval-induced forgetting in recognition tests has also been found in an unpublished study by M.C. Anderson, De Kok and Childs (1997, reported in M.C. Anderson, 2001) using a different set of stimuli that were encoded using a category cue.

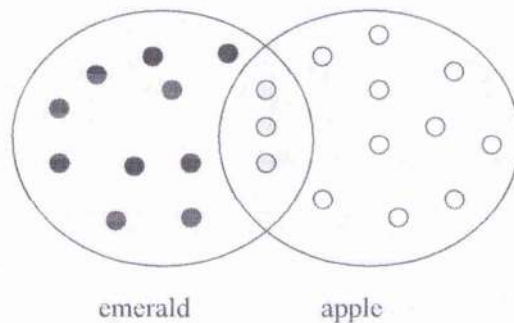
However, this assumption that inhibitory theories predict retrieval-induced forgetting in recognition tests should only be accepted with caution. Not only has very little research examined the recognition memory in retrieval-induced forgetting, but consists of one study that found the effect, another unpublished study, and one under-powered study where retrieval-induced forgetting was not found. Even more troubling is the seeming inconsistency between the predictions made by directed forgetting and retrieval-induced forgetting concerning the use of recognition tests. While an inhibitory account of directed forgetting proposes that the presentation of items at test should release inhibition (e.g., Geiselman et al., 1983), an inhibitory account of retrieval-induced forgetting proposes the converse (e.g., M.C. Anderson,

2001). Although this discrepancy may be due to different forms of inhibition underlying directed forgetting and retrieval-induced forgetting, or inhibition acting at different levels in the retrieval process (e.g., episodic and semantic inhibition), it remains too early to form any firm conclusions.

Inhibitory Models

The failure of non-inhibitory theories to account fully for findings such as the differential effects of exemplar strength and cue-independent forgetting allows the possibility of inhibitory processes to be considered. But what type of inhibitory model might explain these findings? Pattern suppression models have been advanced as the most appropriate account of retrieval-induced forgetting (M.C. Anderson & Spellman, 1995), despite being less computationally developed than other inhibitory models (e.g., lateral inhibition). The advantage of pattern suppression comes from assumptions about how memories are represented in memory and utilises complex memorial representations, which contain internal semantic features that are acted on by facilitatory or inhibitory processes. It is these internal semantic features that allow pattern suppression to account for the unusual findings of second-order inhibition across categories. In contrast, other inhibitory accounts such as lateral inhibition, use discrete and unitary memory representations with no internal features.

Figure 13: Representations of memory traces and internal semantic features in the pattern suppression model



Note. Larger circles represent memorial representations of items, while smaller circles represent the internal semantic features.

In the pattern suppression account, the memorial representation of an item is composed of semantic feature units. Figure 13 demonstrates how items and their internal features are represented in the pattern suppression model. The internal semantic feature units are typically represented as small circles, encompassed by a larger circle that represents where an item 'ends' in memory, separating items from one another. These smaller semantic features can be activated when they are present within an environmental context, or when the features of a related item are activated. The activation of features in a related item is also aided by the assumption that the memorial representations of related items 'cross-over' or 'intersect'. Therefore, if two distinct but related items share semantic features, then the activation of features in one of the items will activate these same features in the related item.

It is the assumptions concerning the organisation of memorial representations that makes the pattern suppression model sufficiently flexible to account for second-order inhibition. Therefore, the presence of various retrieval cues in the environment

will activate all of the semantic features in memory that are associated with it (this does not necessarily mean that all of the features of an item will be activated). The activation of some semantic features of an item will, in turn, activate those remaining items that were not activated by the cue. In terms of the retrieval practice procedure, the presentation of the category cue during the retrieval practice phase will activate all semantic features associated with that cue. For example, the presentation of the retrieval cue RED will activate features associated with that cue that are shared by both BLOOD and CHILLI. In turn, the activation of those features associated with the cue will activate the remaining features of both BLOOD and CHILLI. However, as retrieval practice only requires the selective retrieval of a sub-set of items associated with the cue RED, only the RED-BLOOD association will be practiced. Therefore, as only the semantic features associated with BLOOD will be facilitated by practice, a mechanism is required that inhibits the activated semantic features of competing items, such as CHILLI. Therefore, semantic features associated with the to-be-remembered item will be activated by retrieval practice and suppress competing features in non-target items. As the majority of competitor feature units will be inhibited, competitors should not create competition at retrieval with the to-be-remembered item, and it should not be recalled. In addition, any item that shares inhibited semantic features with those competitors will also share the same fate of inhibition. For example, the majority of semantic features of RED-CHILLI will be inhibited through the retrieval of RED-BLOOD. However, RED-CHILLI shares semantic features with GREEN-PEAS as both items share the implicit category of VEGETABLES. Thus, the retrieval of GREEN-PEAS will be impaired because it shares semantic features with RED-CHILLI. This conclusion is further supported by the finding that second-order inhibition is dependent on NRP-Similar items sharing a

related category with the RP- items (M.C. Anderson & Spellman, 1995). Not only is the second-order inhibition effect dependent on the sharing of related features between RP- items and NRP items, but the retrieval of the NRP-Dissimilar item GREEN-DOLLAR will not be impaired, as it shares semantic features with the RP-item RED-CHILLI. In addition, the recall performance of NRP-Dissimilar items will not be facilitated by the inhibition of NRP-Similar items, an effect predicted by the lateral inhibition model. As the recall of NRP-Dissimilar items in conditions containing related categories was not greater than those items recalled in conditions where there were no related categories, the assumptions of the pattern suppression model are again upheld.

Lateral inhibition models can also account for second-order inhibition. However, according to this account, the magnitude of the second-order inhibitory effect should not be as great as for first-order inhibition due to the suppression of the RP- item and therefore its ability to inhibit related material (i.e., NRP-Similar items). This, therefore, suggests that the recall of NRP-Similar items should not be as impaired as that of the RP- items. Unfortunately, there is little support for this prediction concerning second-order inhibition. For example, M.C. Anderson and Spellman (1995) found that their second-order inhibitory effect was larger than the first-order effect (experiment 2), a finding that is incompatible with lateral inhibition accounts of retrieval-induced forgetting.

In contrast, pattern suppression models predict that the extent of second-order inhibition will be dependent on the degree of overlapping features shared between the RP- items and NRP-Similar items. This latter point suggests that the degree of facilitation and inhibition in pattern suppression models is based on a trade-off between the number of overlapping semantic features that are activated and the

number of overlapping semantic features that are suppressed. This means that a member of the unpracticed category could be suppressed to a greater degree than an RP- item. In an example given by Anderson and Spellman (1995), an RP- item can share 35% of the facilitated semantic features with the RP+ item leading to the remaining 65% of the RP- items feature units being suppressed by the retrieval practice of the RP+ items. This leads to the inhibition of the RP- item. However, if the NRP item shares 95% of its semantic features with the inhibited features of the RP- item, then this NRP item is likely to be subject to more inhibition than the RP- item. The greater inhibition of NRP-Similar items could occur despite the NRP item not being directly related to the RP+ item. Therefore, the pattern suppression model suggests that there are 'degrees' of inhibition, rather than inhibition being a mechanism that is turned 'on' and 'off'. This proposition is also supported by the different degrees of inhibition demonstrated between the suppression of RP- and related NRP items compared to unrelated NRP items, and between items that are strong and weak members of a category.

Pattern Suppression: Evidence for a Two-Factor Model

Research into the effects of integration and similarity on retrieval-induced forgetting has also supplied additional empirical support for the pattern suppression model. This area of research indicates that items that share a high degree of similarity can both eliminate retrieval-induced forgetting (M.C. Anderson et al., 2000b; M.C. Anderson & McCulloch, 1999; Bäuml & Hartinger, 2002), as well as producing robust impairment (M.C. Anderson et al., 2000b; R.E. Smith & Hunt, 2000) – findings which are not easily resolved by interference accounts. Comparable confusion is mirrored in the classic interference literature. Retroactive interference effects have

been found to increase when a high degree of similarity is shared between the paired-associates across lists (McGeoch & McDonald, 1931; Shuell, 1968). On the other hand, increasing similarity between items across list can eliminate retroactive interference (Osgood, 1946, Postman, 1964). To add to the confusion, inter-category similarity has been found to have no effect on the magnitude of the output interference effect (Roediger & Schmidt, 1980). Osgood (1949) referred to such contradictory effects of similarity on recall as the '*similarity paradox*'.

Despite the failure of the classical interference literature to help resolve this issue, the pattern suppression model can accommodate these apparently contradictory findings by examining the effects of similarity at the level of the semantic feature units. The adaptive target discrimination interpretation of retrieval-induced forgetting assumes that the inhibition of competitors increases the discriminability of the target. Thus, the more similar the competitor is to the target, the greater the level of inhibition to which that competing item will be subject. However, this interpretation fails to take into account the effect of retrieving (and therefore activating) those semantic features on a competitor that also shares those activated features. This adaptive account assumes that during retrieval practice, the retrieval of a target item will result in the activation of only those semantic features that constitute the target pattern. Any other patterns that compete for retrieval in response to the cue during retrieval practice will be inhibited due to reduced interference.

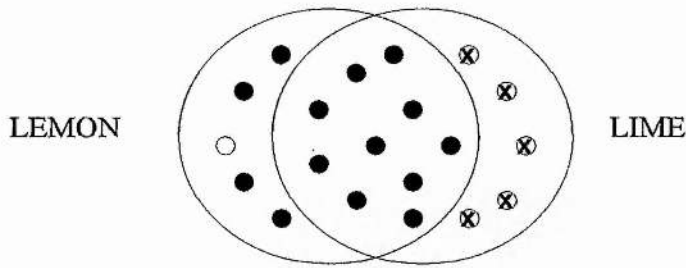
1. Target-Competitor Similarity

This standard interpretation of how the adaptive target discrimination account of retrieval-induced forgetting works within the pattern suppression model is non-specific concerning the fate of competitors that share activated features with a target

item. This variable is what M.C. Anderson et al. (2000b) referred to as '*target-competitor similarity*'. As it is well established that retrieval of an item strengthens that item in memory (Allen et al., 1969; R.A. Bjork, 1975; Carrier & Pashler, 1992), the activation of a target pattern's features will strengthen and facilitate those features. However, the strengthening and facilitation of these features is not restricted to the target pattern. Those semantic features will be strengthened in all competing patterns as well. Therefore, any competing pattern that overlaps with the target pattern will share in those strengthened features, resulting in the facilitation of those features in the competing pattern. The remaining distinct features of the competing pattern will also be subject to a greater degree of inhibition due to the competing pattern being so similar to the target, and because there are fewer distinct features than shared features. This being so, the degree of retrieval-induced forgetting will be dependent on the number of shared strengthened features compared to the number of inhibited distinct features.

This possibility adds a further factor for consideration when trying to predict under what conditions retrieval-induced forgetting is likely to occur. By taking into account the effects of strengthening and facilitation on shared semantic features it is not inevitable that impairment will occur just because a competitor is deemed to be 'similar' to the target. Taking into account this trade-off between shared facilitated features and suppressed distinctive features, any increase in the similarity between a target and its competitors should actually reduce, rather than increase, retrieval-induced forgetting.

Figure 14: An example of the trade off between activation and inhibition

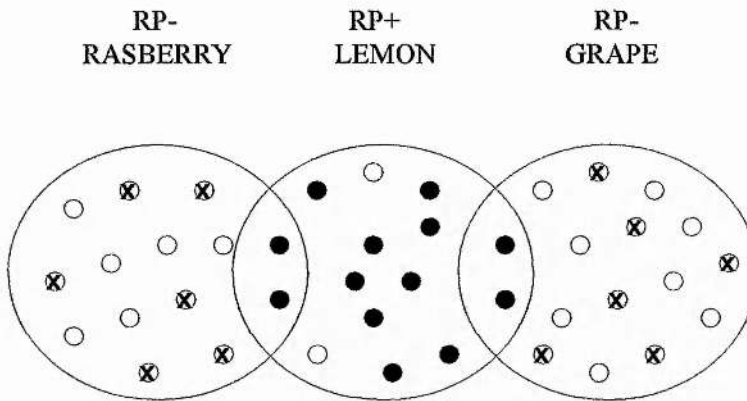


Note. An example of the sharing of semantic features between a target (LEMON) and a similar competitor (LIME). As the target and competitor are both citrus fruits they share a high degree of semantic features. As the retrieval of the target results in the facilitation of its features the competing item's semantic features also benefit.

Figure 14 illustrates this trade-off when a target and competitor are highly similar. As the pattern of the target item LEMON is very similar to that of its competitor LIME it will be very difficult to retrieve selectively the target without also activating its competitor. This will occur because during retrieval practice the features of the target LEMON are strengthened and facilitated through their retrieval. As many of the features of the competing item LIME is shared by LEMON then the shared features in LIME will also be strengthened and facilitated. In addition, in order to try and make the target more distinctive in memory, the remaining unique features of the competitor will be subject to greater inhibition than a less similar competitor. However, the additional inhibition of any remaining unique features is unlikely to be sufficient to overcome the powerful facilitatory effects of the stronger shared features. This can be assumed from the empirical work demonstrating that the facilitatory effects of retrieval tend to be greater than the inhibitory effects. For example, the average facilitation of strong items in M.C. Anderson et al. (1994) was

16.3% and the average inhibitory effect was 11%. Therefore, during final recall, the competitor LIME should be recalled. This is exactly what Bäuml and Hartinger (2002) found using sets of sub-categories within larger categories. Retrieval-induced forgetting effects were abolished when the RP+ and RP- items shared both a category and a sub-category.

In contrast, where a target and competitor are highly similar, retrieval-induced forgetting is expected to occur when the similarity between a target and competitor is decreased. For example, in Figure 15, both the target LEMON and its competitor STRAWBERRY are from the same category FRUIT but both items are fairly distinctive within that category. This being so, the competing STRAWBERRY will share fewer semantic features with the target LEMON and so will not create as much interference at retrieval. Therefore, during retrieval practice, the retrieval of the target will result in the strengthening and facilitation of its features. However, the competing item shares very few of these strengthened features. In addition, as the competitor's pattern is not very similar to the target pattern, it is unlikely to be a particularly strong competitor. Due to this, not all of its remaining unique features will be subject to inhibition. Only a proportion of the competitor's features will need to be inhibited in order to increase the target item's pattern more distinctiveness in memory. However, because the competing pattern is subject to more inhibition than facilitation it is unlikely to be retrieved at recall. This prediction of category members being inhibited is supported by the majority of retrieval-induced forgetting studies (e.g., M.C. Anderson et al., 1994, M.C. Anderson et al., 2000b; M.C. Anderson & Spellman, 1995; MacLeod, 2002; Macrae & MacLeod, 1999).

Figure 15: Target-competitor similarity

Note. The black circles represent facilitated semantic features, while the circles containing crosses represent inhibited features. When target-competitor similarity is only moderate the competing RP- items do not share many features with the RP+ item. Thus, the RP- items share few strengthened features, but also, as these items are only moderate strength competitors, they are also not subject to strong inhibition.

M.C. Anderson et al. (2000b) directly tested the predictions of the pattern suppression model of manipulating target-competitor similarity in retrieval-induced forgetting. Sets of triple words were used as stimuli and were composed of a cue and two category members (e.g., RED Tomato Radish). In an initial study phase, participants completed a judgement task that required participants to rate how good an example each item was as an example of a category member. This task encouraged participants to encode each item individually and associate it to the category cue thereby creating competition. The judgement task also attempted to control and reduce any natural encoding strategies that see the category members being associated to one another rather than to the category label. With all participants having initially encoded the stimuli in a similar manner, participants were required to either find similarities or differences between an item that would later receive retrieval practice

(e.g., the target item 'Tomato') and another item that would not receive practice (e.g., the competing item 'Radish').

The results supported the predictions of the pattern suppression model. When similarities were encoded between a target and a competitor, retrieval-induced forgetting effects were eliminated and reversed. Under these encoding conditions participants recalled more RP- items than NRP items. This is also consistent with Bäuml and Hartinger's (2002) findings that, inter-relating the RP+ and RP- items through sharing a sub-category, facilitates the later recall performance of RP- items. Therefore, it is assumed that target-competitor similarity is increased through increasing the number of shared facilitated features between the RP+ and RP- item. In contrast, when target-competitor similarity is reduced through the encoding of unique properties a strong retrieval-induced forgetting effect was found. This is also in line with Bäuml and Hartinger, who found that when RP+ items were drawn from the same category but a different sub-category, a robust retrieval-induced forgetting effect was demonstrated. The pattern suppression model assumes that decreasing target-competitor similarity reduced the number of shared facilitated features leaving the remaining unique features of the RP- items vulnerable to inhibition. In addition, as M.C. Anderson et al. (2000b) employed novel cues at recall, it can be asserted that the features of the RP- items were subject to inhibitory processes.

II. Competitor-Competitor Similarity

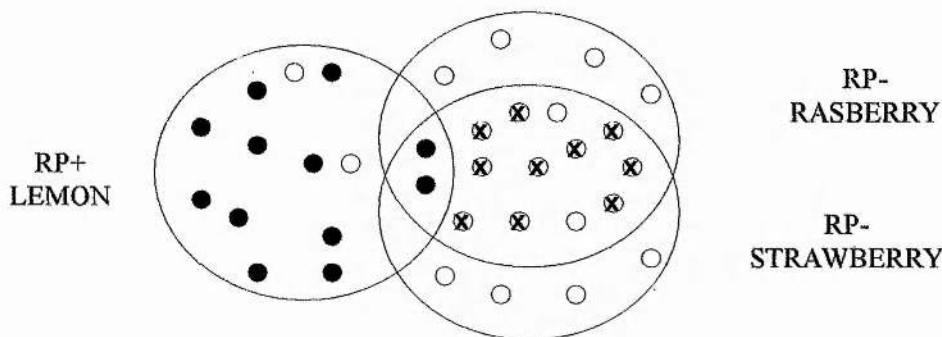
As already noted, under some circumstances, attempts to decrease the similarity between items has led to both the elimination of retrieval-induced forgetting (R.E. Smith & Hunt, 2000), and the production of strong impairment (Bäuml & Hartinger, 2002). The pattern suppression model suggests that shared inhibited features between

competitors may explain these apparently contradictory results: what M.C. Anderson et al. (2000b) referred to as '*competitor-competitor similarity*'. This variable is likely to influence the pattern of recall when there is more than one item competing with the target. As competing patterns can create interference during retrieval, the unique features of the competitors are inhibited in order to increase the discriminability of the target. However, if the competitors are similar to one another, with many overlapping features, these items are likely to share many inhibited features. Under these conditions, the inhibition of shared features is likely to have a greater net inhibitory effect than if the same number of features were inhibited in less similar competitors (e.g., when the competing items are RASBERRY and GRAPE). It is under these conditions of high competitor-competitor similarity that the strongest retrieval-induced forgetting effects are likely to occur. Figure 16 demonstrates a situation where competitors are highly similar to one another. These competing items in these two examples do differ in their similarity to one another with many overlapping features.

During retrieval practice, the features of the target LEMON are strengthened and facilitated through their retrieval. However, very few of these strengthened features are shared with the competing items, and so only a minimal number of features in the patterns of competing items is facilitated. The remaining unique features of the competitors will be subject to inhibition in order to reduce interference created by these competing items. As these competing patterns are not overly similar to the target, as indicated by the few shared facilitated features, their individual patterns would normally be subject to weak to moderate levels of inhibition only (see Figure 16). However, as competitor-competitor similarity increases, the patterns of competing items will become more similar to one another due to an increase in the

number of shared many features. In addition, these items are likely to share inhibited features. The effects of sharing inhibited features is thus likely to create a larger inhibitory effect than if less similar competitors were subject to inhibition separately. M.C. Anderson et al. (2000b) referred to this increased net inhibitory effect as the inhibited features doing 'double duty' to indicate that sharing inhibited features impairs patterns to a greater degree than the same number of features being inhibited in unsimilar competitors. Under these conditions of high competitor-competitor similarity a strong retrieval-induced forgetting effect is expected.

Figure 16: Competitor-competitor similarity



Note. The black circles represent facilitated semantic features, while the circles containing crosses represent inhibited features. When competing items share many features, they are likely to share many inhibited features, thereby increasing the net inhibitory effect.

M.C. Anderson et al. (2000b) interpret the elimination of retrieval-induced forgetting through encoding differences between items (R.E. Smith & Hunt, 2000) within this competitor-competitor framework. The task of encoding differences between items may not eliminate retrieval-induced forgetting through making the

pattern of the target more distinctive but instead this task may make the pattern of the competitors more unique from one another. That is, retrieval-induced forgetting was attenuated through decreasing competitor-competitor similarity.

As this work on distinctive encoding did not specifically addresses competitor-competitor similarity within the pattern suppression model, M.C. Anderson et al. (2000b) set about testing the model's predictions that varying the relatedness of competing items to one another will also vary the magnitude of the retrieval-induced forgetting effect in specific directions. Participants were presented with sets of word triplets (e.g., RED Tomato Radish) and initially associated each category members to its category label. Following this initial encoding task, participants were required to find either similarities or differences between the competitors (e.g., Tomato Radish). These pairs of category members would either receive retrieval practice in the following phase (making these items target pairs), or the word pairs would receive no practice, making these items competitors.

M.C. Anderson et al. (2000b) found that the effects of encoding similarities or differences between competitors had a significant impact on the pattern of recall. When similarities were encoded between competitors, significant retrieval-induced forgetting effects were found. This result supported R.E. Smith and Hunt's (2000) prior findings of significant impairment when similarities are encoded between category members. It is assumed that the number of inhibited features shared by the competitors is raised through encoding competitors in the manner as well as resulting in a decrease in the number of unique features for each individual competitor. In contrast, when differences were encoded between competing items, retrieval-induced forgetting was eliminated. This result was also in line with the finding by R.E. Smith and Hunt that encoding differences between category members eliminated retrieval-

induced forgetting. It is assumed that decreasing this competitor-competitor similarity reduced the number of shared inhibited features between the items and increased the number of features unique to each individual competitor. This reduction in the number of shared inhibited features through the promotion of unique properties is expected to have reduced the net inhibitory effect acting on the RP- items. In addition, category members were cued at recall using novel cues ensuring that the features of RP- items were subject to inhibition.

In conclusion, the contradictory results of Bäuml and Hartinger (2002) and R.E. Smith and Hunt (2000) can be accommodated within the pattern suppression model. Bäuml and Hartinger clearly manipulated target-competitor similarity by drawing the RP- items from either the same sub-category or a different one. Despite being a less clear manipulation, the focus of R.E. Smith and Hunt's study appears to have been to increase the similarity between items that could potentially act as competitors, as well as increasing similarity between targets and competitors. However, as the retrieval-induced forgetting effect in M.C. Anderson et al. (2000b) increased with a corresponding increase in competitor-competitor similarity, the findings of strong retrieval-induced forgetting effects though encoding similarities in the R.E. Smith and Hunt study may also be due to an increase in competitor-competitor similarity. With this interpretation in mind, the elimination of retrieval-induced forgetting with distinctive encoding may also have been due to a reduction in competitor-competitor similarity. This account of R.E. Smith and Hunt's encoding instructions is supported by the additional finding of M.C. Anderson et al. (2000b) that increasing target-competitor similarity reversed the retrieval-induced forgetting effect, a pattern of recall opposite to increasing competitor-competitor similarity. Of course, R.E. Smith and Hunt's encoding instructions also included a target-competitor

manipulation as well, which is not accounted for. Varying the similarity of the competitor to the target should also have affected the recall of the RP- items. However, M.C. Anderson et al. suggest that the instructions to encode similarity or differences between one item and the remaining category members may have resulted in many partial comparisons that were rejected because the comparison did not apply to all category members. The encoding, but rejection, of many possible comparisons may have increased the number of competitor-competitor similarities or differences. By increasing the number of independent competitor-competitor similarities between some members of the category, retrieval-induced forgetting could be increased. In contrast, encoding many independent unique features between a sub-set of competing items will also have made these items more resistant to retrieval-induced forgetting. In addition to this possibility, it is unknown what effect encoding both target-competitor similarities *and* competitor-competitor similarities has on the net retrieval-induced forgetting effect predicted by the pattern suppression model. Given that subsequent retrieval is easily facilitated by the retrieval of an item from memory, perhaps encoding competitor-competitor similarities is a more potent and distinctive event than encoding target-competitor similarities.

Difficulties in the Inhibitory Account of Retrieval-induced Forgetting: Theoretical or Experimental?

There has, however, been mixed evidence in support of the inhibitory account of retrieval-induced forgetting, although this appears to be primarily due to methodological weaknesses. For example, Williams and Zacks (2001) attempted to reproduce cue-independent forgetting using different categories to that originally used by M.C. Anderson and Spellman (1995). However, Williams and Zacks may have

misinterpreted inhibitory theories, mistaking cue independence in retrieval-induced forgetting (i.e., first-order inhibition) for that of second-order inhibition. Thus, Williams and Zacks dismiss their marginally significant retrieval-induced forgetting effects with the independent probe method ($p < 0.07$), and concentrate on their failure to find second-order inhibition (an effect that is not in itself predicted by inhibitory theories, but which can be accommodated by them to a better degree than non-inhibitory theories).

Unfortunately, there are other methodological weaknesses in the study, which may explain the weak retrieval-induced forgetting effect as well the failure to find second-order inhibition. For example, one serious problem concerns the strength of the category exemplars, which varied dramatically, and according to Battig and Montague (1969), averaged 19.1 and ranged from 2 to 53. This means that the average strength of the category members was only moderate, and while some members were extremely strong, other were very weak exemplars of their category. In the case of these very weak exemplars, if an inhibitory mechanism was present it is unlikely to be triggered due to their lack of competitive strength. In fact, weak RP-items are more likely to be facilitated by their relatedness to practiced items (M.C. Anderson et al. 1994). A further difficulty with Williams and Zacks (2001) interpretation against an inhibitory account of retrieval-induced forgetting concerns how they tested recall. It is unclear what type of test was used, although it is assumed to be the same category cue plus free recall test that was employed in the other studies reported by Williams and Zacks in their examination of the effects of exemplar strength on retrieval-induced forgetting. Also, output interference effects could not be dismissed as possible influences on the observed pattern of recall.

A loss of inhibitory control has also been put forward to explain memory deficits in older adults and patients with Alzheimer's disease (Hasher & Zacks, 1988; Hasher, Zacks & May, 1999), although facilitatory effects are believed to remain intact (Faust et al., 1997). Based on the assumption that inhibitory control declines with advancing years, older adults should show less retrieval-induced forgetting than do younger adults, resulting in more competing items vying for retrieval and increased retrieval times. Moulin, Perfect, Conway, North, Jones and James (2002) examined retrieval-induced forgetting effects in a population of patients with Alzheimer's disease, and matched healthy older adults. Retrieval-induced forgetting effects were found in both groups, and the size for the effect in the Alzheimer's group was of a similar magnitude to that found for the healthy older adults. Moulin et al. (2002) interpret this result as indicating that the inhibition of competing items in episodic memory remains intact in Alzheimer's disease, and that this form of inhibition is a "low-level attentional process" (p. 866). However, it is difficult to assess whether this study actually measured inhibitory processes or not. For a study that makes claims that there are inhibitory deficits in the episodic memories of patients with Alzheimer's disease, it would be necessary to rule out non-inhibitory effects first. For example, the cued-recall task that was employed by Moulin et al. is similar to that used in experiment one of M.C. Anderson et al. (1994) where the retrieval-induced forgetting effect was obscured by output interference. However, just like Williams and Zacks (2001), Moulin et al. never controlled for output order during the experiment by employing a cue-plus-stem recall test, or calculate post-hoc whether any output interference effects were present. Given the use of an immediate test after retrieval practice, where it could be argued that output interference effects could be at their strongest, and the fact that older people are more susceptible to

interference effects, calculating the presence of output interference would have been desirable. This failure to calculate output interference seems a particularly critical omission given M.D. MacLeod's (2003) findings that older adults retrieval-induced forgetting effects may be strongly influenced by output interference, while younger adults are not.

Koutstaal et al. (1999) also examined the abilities of older healthy adults to inhibit competing information. Older adults acted out a set of actions during the study phase and then reviewed a sub-set of these items through photographic cues two days later. Four measures of recall were measured during a free recall task: general recall of activities, number of objects, number of actions, and number of pictorial or conceptual representations. In all four measures of performance, retrieval-induced forgetting effects were found. However, like Moulin et al. (2001), Koutstaal et al. failed to determine if output interference was operating during retrieval. Therefore, it is unknown whether the impaired recall of RP- items was more likely to be due to the specific inhibition of those items, or the blocking of weaker RP- items by the earlier output of the stronger RP+ items.

The active inhibition of memorial representations has been investigated using other implicit memory tests that vary in their perceptual and conceptual properties. Butler, Williams, Zacks and Maki (2001) examined whether retrieval-induced forgetting could be found using various memory tests. As already demonstrated, retrieval-induced forgetting has been found using category cue plus free recall (M.C. Anderson et al., 1994; Moulin et al., 2002; Williams & Zacks, 2001), category member generation (Moulin et al., 2002), and cue-plus-stem recall (M.C. Anderson et al., 1994; M.C. Anderson et al., 2000a; Bäuml, 2002). It is assumed that if the memorial representation of the RP- item is truly inhibited, then it should not matter

what kind of test is employed, retrieval-induced forgetting effects should be found. Butler et al. (2001) studied retrieval-induced forgetting in the category cue plus free recall task, as well as word-fragment tasks (with and without an episodic cue referencing participants back to the study phase, or with a category cue), and the cue-plus-stem task previously employed by M.C. Anderson and colleagues (M.C. Anderson et al., 1994; M.C. Anderson et al., 2000a; M.C. Anderson & Spellman, 1995). However, significant RP- impairment was detected only in the cue plus free recall task, and RP- performance actually improved with the use of the cue-plus-stem task typically used by M.C. Anderson and colleagues. There are difficulties, however, in interpreting these results due to methodological issues. In the cue plus free recall condition, Butler et al. did not calculate if output interference effects were present, making it difficult to ascertain whether the pattern of RP- impairment was due to the inhibition of the RP- items during retrieval practice, or the blocking of weaker RP- items by the stronger RP+ items during the retrieval stage. In addition, output interference effects were not controlled for during the remaining memory tests, nor calculated post-hoc. While the cueing of every target items at test was randomised, no effort was made to ensure that the weaker RP- or NRP items were recalled before the stronger items. This being so, Butler et al. needed to calculate whether the impairment in the RP- performance was due to the uncontrolled output of items at test or not. It should also be noted that Butler et al. used stimuli of a moderate strength, as ranked by Battig and Montague (1969), which may have contributed to the weak retrieval-induced forgetting effect in the cue plus free recall condition, and its absence in the remaining test conditions. Despite these issues, Butler et al. suggested that retrieval-induced forgetting may be absent in conditions where memory tests reinstate strong contextual cues for individual items, a conclusion

supported by Koutstaal et al. (1999). Conditions where word-fragments are used could be considered one of the strongest cueing conditions possible without actually re-presenting the item. However, Koutstaal et al.'s account of retrieval-induced forgetting is inconsistent with inhibitory theories and is actually more akin to the encoding specificity hypothesis, which is a cue-dependent forgetting account of retrieval failures (Tulving, 1974; Tulving & Osler, 1968; Tulving & Thompson, 1973; Wiseman & Tulving, 1976).

Beyond Word Lists: Visual Materials and Retrieval-induced Forgetting

As the inhibition of competing information has been advocated as an adaptive process that recruits inhibitory processes in order to maintain a flexible and stable memory system (e.g., M.C. Anderson & Green, 2001; E.L. Bjork et al., in press; R.A. Bjork, 1989; Dagenbach & Carr, 1994), it is essential that retrieval-induced forgetting is found using materials more in keeping with everyday social cognition tasks. If, however, retrieval-induced forgetting can only be found using word lists, then the assumption that it serves an adaptive function in everyday memory may be misplaced. Retrieval-induced forgetting has already been demonstrated using materials that are highly organised in memory, such as semantic categories, suggesting that information stored in implicit categories in long-term memory is susceptible to the effect (e.g., M.C. Anderson et al., 1994; M.C. Anderson et al., 2000a; M.C. Anderson & Spellman, 1995; Bäuml & Hartinger, 2002; R.E. Smith & Hunt, 2000). Can retrieval-induced forgetting, however, also be found with other types of materials, such as meaningful stimuli occurring within a context *other* than lists of words? Can the inhibition of competing information persist even when participants are highly motivated to try and recollect all relevant materials?

Perhaps one of the most unusual sets of materials employed in a retrieval-induced forgetting study is that of the sets of visuo-spatial stimuli used by Ciranni and Shimamura (1999). While these materials could be grouped by shape (i.e., 4 circles, 4 triangles, 4 crosses), each item also had a distinct colour and location. Retrieval practice consisted of participants retrieving a sub-set of items using shape and location as cues (i.e., 2 circles, 2 triangles), and having to recall the colour of all of the items at final recall. Ciranni and Shimamura (1999) found that the retrieval of a sub-set of items from one perceptual group (i.e., shape) resulted in the impaired recall of the remaining items from that group. This finding of impaired RP- performance was found despite participant's attention not being explicitly drawn to the shape category. That is, participants organised stimuli into this arbitrary category of shape even though each item had its own unique colour and location. With this distinctive information, participants could have completed the tasks without relying on the implicit grouping category, which resulted in impairment. In addition, this retrieval-induced forgetting effect was found not only when items were cued at final recall using the same cue that was used at retrieval practice, but also when the original cues employed during encoding were used. This latter point suggests that, as different cues were used to the ones that RP+ items were strengthened under, then the strengthened RP+ items were not blocking the retrieval of weaker RP- items. The elimination of a strength-dependent explanation suggests that inhibitory processes may be functioning under these conditions.

Retrieval-induced forgetting effects have also been investigated using complex, and more natural visual materials. Koutstaal et al. (1999) had participant's act out a set of activities, which should have provided a rich memorial context and produced many possible retrieval routes to the target information. Two days later

participants either 'reviewed' half of those items or complete a set of unrelated tasks. This review task consisted of participants viewing photographs of other individuals performing some of the tasks that the participants themselves had completed two days earlier and to try and recall themselves performing these activities. Significant retrieval-induced forgetting effects were found for the number of general activities that participants recalled, and for the number of objects that were recalled. Marginally significant impairment was also found for the number of actions that were recalled, and for the number of pictorial or conceptual representations that had been acted out in the study phase. Despite these latter measures being only marginally significant ($p < .10$ to $.15$), the size of the retrieval-induced forgetting effect was actually quite large ($-.13$), compared to the size of effect found in other studies (e.g., $-.08$ in M.C. Anderson et al., 1994). This marginal significance is likely to be due to the between-participants design and the likelihood that the study was under-powered (only twelve participants in each condition). Similar problems can be found in a second study where retrieval-induced forgetting was not found using a combined cued-recall/recognition task, where there were only eight participants in each condition.

Temporal Boundaries of Retrieval-induced Forgetting

Retrieval-induced forgetting has been advanced as an adaptive process in long-term memory that can prevent related competing information, and out-of-date information, from interfering with the retrieval of target information in order to satisfy some memorial goal (e.g., M.C. Anderson et al., 1995; M.C. Anderson & Spellman, 1995; E.L. Bjork et al., in press; R.A. Bjork, 1989; M.D. MacLeod & Macrae, 2001; Macrae & MacLeod, 1999). This being so, if retrieval-induced forgetting is to be assigned an

adaptive role in the retrieval of information from memory to complete every day tasks, then time becomes a potential boundary condition (M.D. MacLeod & Macrae, 2001). One of these boundaries is that the inhibition of competing memorial representations is not constrained by the age of the memory. In the typical retrieval-induced forgetting paradigm, retrieval practice immediately follows the encoding of the target materials. However, there are few opportunities in daily life where retrieval practice would occur immediately after encoding information. It is more likely that the selective retrieval of information would occur some time after an event or information was experienced. Thus, in order for retrieval-induced forgetting to serve an adaptive function, it must still be elicited when retrieval practice occurs long after original encoding.

M.D. MacLeod and Macrae (2001) examined this potential temporal boundary in an impression formation task. After forming impressions of two individuals, 24-hours elapsed between this initial encoding and the eventual retrieval practice of a sub-set of personality traits about one of the targets. Despite this significant retention interval, a robust retrieval-induced forgetting effect emerged. Although impairment in RP- performance was smaller than that found in a similar condition where retrieval practice was immediate, this was primarily due to a decrease in the NRP baseline. Similarly, Koutstaal et al. (1999) found retrieval-induced forgetting effects when a two-day delay was inserted between study and retrieval practice.

The adaptive role assigned to retrieval-induced forgetting (e.g., M.C. Anderson, 2001; E.L. Bjork et al., in press; Levy & M.C. Anderson, 2002; M.D. MacLeod & Macrae, 2001; Macrae & MacLeod, 1999) also places potential constraints on the duration of the effect. According to this adaptive interpretation of inhibition, the primary constraint on the temporal duration of inhibition is whether a

goal state has been satisfied or not. Therefore, it can be assumed, that for certain types of information, this inhibition will be transitory, while for other types of material, inhibition may be longer lasting, or even permanent. As goal states are constantly changing (Bodenhausen & Macrae, 1998; Macrae & Bodenhausen, 2000), inhibition need only last long enough to satisfy the current goal-state. If inhibition was to endure after having satisfied current cognitive goals, then the successful completion of future goals could be compromised. That is, while unwanted information may be currently inhibited to prevent it interfering with the target material, today's unwanted information may be tomorrow's target material. Therefore, under many circumstances it would not be adaptive to subject information to either long-lasting or permanent inhibition. Despite this, there are situations where it could potentially be adaptive to subject information to either extremely long-lasting inhibition, or to permanently inhibit that information, such as very old, irrelevant, or false information, and unwanted or traumatic memories (M.C. Anderson, 2001; M.C. Anderson & Green, 2001; Freyd, 1996; Levy & M.C. Anderson, 2002; M.D. MacLeod et al., 2003). However, under conditions where information *is* permanently inhibited, it would be impossible to between erasure and inhibition.

As the adaptive account of retrieval-induced forgetting predicts that, under 'ordinary' circumstances, inhibition should only remain evident until a goal has been satisfied, then retrieval-induced forgetting should only be found under circumstances where the retention interval between retrieval practice and delay is relatively short. This retention interval is likely to control the duration of inhibition as the goal of resolving retrieval competition occurs during the retrieval practice phase (M.C. Anderson et al., 1994; M.C. Anderson et al., 2000a; M.C. Anderson & Spellman, 1995). Studies have found retrieval-induced forgetting effects with various retention

lengths following retrieval practice, varying from immediate tests (Ciranni & Shimamura, 1999; Moulin et al., 2002), through to 20 minute delays (e.g., M.C. Anderson et al., 1994; R.E. Smith & Hunt, 2000). As inhibition in other cognitive domains typically lasts for much briefer periods of time (e.g., Tipper, 2001), the finding that inhibition elicited during retrieval can last at as long as 20 minutes is of considerable importance.

How long does it take for the effect to dissipate? The answer to this question most probably depends on an individual's goals (see M.D. MacLeod et al., 2003). During many information-processing tasks it would be an undesirable feature of memory if this inhibitory effect were long lasting. For example, inhibition should be relatively short-lived during the resolution of retrieval competition for information relevant to daily life, such as telephone numbers, car parking spots, shopping lists, etc. M.D. MacLeod and Macrae (2001) have demonstrated that retrieval-induced forgetting is a transitory effect that dissipates when the previous goal (i.e., retrieving RP+ items during the retrieval practice phase) becomes irrelevant. In the case of the impression formation task employed in M.D. MacLeod and Macrae, inhibition dissipated over a 24-hour period subsequent to the retrieval practice phase, with slight recovery in recall performance for RP- items.

Changing Goal States: Unintended Consequences of Prior Retrieval

Thus far, retrieval-induced forgetting and inhibitory processes have been advanced as an adaptive process that allows for competition between similar items to be resolved without the permanent erasure of those competitors. Despite such positive interpretations, forgetting can have unintended consequences. For example, how might the prior retrieval of a sub-set of items affect subsequent memory performance

for individuals who are highly motivated to recall as much information as they can? One such condition where individuals are highly motivated to remember as much of the target material as possible is examinations. Individuals who wish to perform to the best of their abilities typically revise material through study techniques, such as answering mock test questions that may appear on the exam script. As the prior retrieval of information facilitates the likelihood of that information being retrieved in the future, then any questions in an exam that refers to this practiced information should be answered relatively easily. However, if an exam question refers to unpracticed information from a previously revised topic, then individuals may actually perform more poorly than others who have not revised any information from that same topic.

Macrae and MacLeod (1999) examined whether participant's motivation to do well in exams would circumvent retrieval-induced forgetting and prevent it from interfering with performance. Participants were informed that they would be taking part in a mock geography exam and were required to study twenty facts about two islands (fictitious). During retrieval practice, half of the items from one of the islands were repeatedly retrieved. Following a distracter task, participants were prompted to recall as many facts as possible about both of the islands. Despite knowing that they would be tested on their knowledge of the two islands, participants still recalled fewer unpracticed facts that came from the same set as the practiced items, than participants engaged in non-relevant retrieval practice. Thus, while a period of review in preparation for an exam can be beneficial to performance for those revised items, it can also have the unintentional consequence of impairing recall for related, but non-reviewed items.

People are also aware of the consequences of forgetting in social-information processing scenarios, such as impression formation, and eyewitness scenarios. For example, not only do participants demonstrate impaired recall of RP- traits after forming impressions of individuals, (Macrae & MacLeod, 1999; M.D. MacLeod & Macrae, 2001), but retrieval-induced forgetting has also been found to prevent both individuating and stereotypic information about an individual from being retrieved (Dunn & Spellman, 2003). More specifically, when participants performed retrieval practice on either individuating or stereotypic traits this prior retrieval was found to inhibit participant's recall of the other type of trait. While the suppression of stereotypical information may be beneficial, especially given that the intentional suppression of stereotypical information has been found to be fairly ineffective (Macrae, Bodenhausen, Milne & Ford, 1997), inhibition of individuating information may result in the maintenance of inaccurate beliefs about individuals based on group membership.

Retrieval-induced forgetting has also been examined under mock eyewitness contexts, where it is critical that participants recall as many details as possible. Shaw et al. (1995) noted that the repeated questioning of eyewitnesses during a police interrogation might elicit the same set of mechanisms as the retrieval practice procedure elicits. This is because the retrieval practice procedure and the interrogation of witnesses are similar in two basic respects. The first is that the questioning of witnesses constitutes an *incomplete retrieval task*, much like the retrieval practice procedure. It is not pragmatic to expect police officers or solicitors to be able to ask every question relevant to every aspect of an incident encoded in a witness' memory. Thus, the questioning of an eyewitness will always be incomplete, as will the witness' re-telling and reconstruction of the event.

The second is that, just as participants are encouraged to repeatedly retrieve the same sub-set of items over and over again in the retrieval practice procedure, witnesses are also typically questioned repeatedly about an incident by both the police and, if the case goes to court, by solicitors. It is generally accepted that this type of questioning has beneficial effects on the retrieval of information from a witness. Even alternative methods to that of the standard police interview, such as the cognitive interview, employ repeated questioning as the basis for gaining a complete account of what happened (e.g., Fisher & Geiselman, 1988). However, any notion that the questioning of witnesses is merely taking account of what an individual perceived during a criminal incident is inappropriate.

The notion that the actual retrieval of information could result in an incomplete account of an incident, and that this could be due to inhibitory processes was a novel approach to the problem of interviewing eyewitnesses. An inhibitory account has the potential not only to explain why the statements of eyewitnesses typically contain only a proportion of the information encoded during an incident, but also why witnesses have difficulty in recognising a suspect after verbally describing that individual (i.e., verbal overshadowing effect, Schooler & Engstler-Schooler, 1990).

Shaw et al. (1995) altered the standard retrieval practice procedure (i.e., M.C. Anderson et al., 1994) in order to make it more applicable to studying eyewitness memory. Instead of using paired-associates that are highly organised within semantic memory, visual materials were used that consisted of slides depicting an incident concerning the theft of a wallet at a party. In addition, sets of questions that increased in difficulty with each preceding set were employed during retrieval practice in order to maximise the effects of retrieval (Landauer & Bjork, 1978). These questions

required participants to retrieve information repeatedly from the slides in a mock interrogation phase. Finally, a 'no interrogation' control condition was employed in order to compare with the positive and negative consequences of interrogation.

A significant retrieval-induced forgetting effect was found in the interrogation condition, suggesting that the repeated retrieval of information in response to interrogation can impair the recall of related but unretrieved information. Practice and retrieval-induced forgetting effects were absent in the no interrogation condition, demonstrating that while the absence of questioning does not facilitate the subsequent retrieval of information, it also does not directly impair the retrieval of information either. In addition, while more RP+ items were recalled compared to the no interrogation condition, fewer RP- items in the interrogation condition were also recalled. This suggests that while prior retrieval of information about an incident facilitates the later recall of those items, it can also impair the recall of related information that has not been previously retrieved. Unfortunately, the retrieval-induced forgetting effect in Shaw et al. (1995) was obscured by the possible presence of output interference operating during the final recall phase. Practiced items were more likely to feature in the first three recall positions than the last four positions, suggesting that these stronger items may have blocked the subsequent recall of the weaker RP- items.

More recently, M.D. MacLeod (2002) found significant retrieval-induced forgetting effects in two eyewitness memory paradigms even when output interference was eliminated. Both studies used complex visual materials presented as a series of slides. In one study, participants were asked to pay close attention to a series of slides, as they were to imagine that they were police officers investigating two burglaries. The slides contained items that had been stolen from each house, and

fell into two semantic categories (electrical and non-electrical items). In the second study, participants viewed a series of slides depicting two women making bogus charity collections. The target information contained within these slides was the appearance of two suspects and thus did not fall into well-organised explicit categories. However, prior pilot work demonstrated that every individual who viewed these slides noted that one of the women had brown hair and the other had blonde hair. Thus, the target information formed two implicit categories. Participant's attention was not specifically drawn to the two women, but instead, participants were told that they were to imagine that they had witnessed the event. Thus, the slides not only contained the two suspects, but also placed those suspects within a context of them going from door-to-door collecting money.

M.D. MacLeod (2002) demonstrated that the repeated questioning of witnesses could lead to the impaired recall of related information that was not retrieved in response to a question. In addition, this effect still occurs when individuals are motivated to remember, and when attention is not explicitly drawn to target material. M.D. MacLeod's study also represented the only empirical work examining the effects of retrieving a sub-set of details about the description of an individual. This study suggests that retrieval-induced forgetting can occur when an individual is attempting to describe a suspect's appearance, and implies that not only is an eyewitnesses' statement about an incident susceptible to inhibition, but also the description of a suspect. Research on the verbal overshadowing effect has already demonstrated that verbally describing a face using free recall procedures can lead to impaired recognition of that face on a subsequent test (e.g., Schooler & Engstler-Schooler, 1990). As the retrieval of only a sub-set of items describing a suspect's appearance also results in an impaired ability to describe that suspect at a later date, it

may be that the inhibitory mechanism underlying retrieval-induced forgetting is also responsible for the verbal overshadowing effect. This interpretation of the verbal overshadowing effect is strengthened by the finding that the cognitive interview, which is also based on incomplete retrieval of information, is also susceptible to verbal overshadowing (Finger & Pezdek, 1999). This being so, the retrieval of information concerning the face of a suspect, and their general appearance, may be especially susceptible to inhibitory effects. This is of considerable importance for successful police investigations given that the description of a suspect is used for the construction of line-ups and photo-fits.

The results of both Shaw et al. (1995) and M.D. MacLeod (2002) also have interesting possible implications concerning the use of interrogation procedures that utilise repeated and selective questioning of witnesses. Procedures such as the cognitive interview (Geiselman et al., 1985), are based on various principles taken from cognitive psychology, particularly the encoding specificity principle, and have successfully made the transition from the laboratory to the field. This interviewing technique has been advanced as being more efficient at extracting information from witnesses as well as reducing the number of 'honest errors' made by well-meaning eyewitnesses. However, the basis of the cognitive interview is the repeated questioning of witnesses through mental reinstatement, different temporal orders, and different viewpoints. Thus, this method is likely to be just as susceptible to retrieval-induced forgetting as the standard questioning method.

The findings of retrieval-induced forgetting with very different materials, and under various goal-directed forgetting conditions, suggests that this process is both adaptive and flexible. As retrieval-induced forgetting operates within even the most complex visual contexts (e.g., M.D. MacLeod, 2002), and abstract materials (Ciranni

& Shimamura, 1999), it strongly suggests that the inhibition of competing information is likely to function under everyday remembering and forgetting conditions.

Having established that retrieval-induced forgetting is not constrained by factors such as materials (e.g., Ciranni & Shimamura, 1999), or explicit instructions to encode information (e.g., Macrae & MacLeod, 1999), one major constraint could be that target information must be repeatedly retrieved. In a typical study, participants would normally engage in three retrieval practices (e.g., M.C. Anderson et al., 1994; Bäuml & Hartinger, 2002; Ciranni & Shimamura, 1999; R.E. Smith & Hunt, 2000). If this repeated retrieval were necessary to produce the effect then the adaptive role of retrieval-induced forgetting, and its underlying inhibitory processes would be severely curtailed. However, research has demonstrated that information does not have to be repeatedly retrieved from memory in order to elicit inhibition. There is no significant difference between the magnitude of the retrieval-induced forgetting effect when participants have engaged in either one, three, or six retrieval practices (Macrae & MacLeod, 1999). The only other study not to employ the typical three retrieval practices is that of Hicks and Starns (in press) who found RP- impairment with only two retrieval practices. This is not to say, however, that more retrieval practices might not result in more inhibition, especially given M.C. Anderson and Green's (2001) finding of increasing suppression effects when the number of suppression trials is increased from one to sixteen in the Think/No-Think paradigm.

Protecting Memories from Inhibition

The inhibition of competitors has so far been advanced as an adaptive feature of memory that reduces interference from outdated information (R.A. Bjork, 1989), and aids the discrimination of targets from competitors (Dagenbach, Carr & Barnhardt,

1990; M.C. Anderson & Spellman, 1995). For example, second-order inhibition suggests that competitors that are highly similar to one another will be subject to inhibition in order to increase the discriminability of targets in memory (M.C. Anderson & Spellman, 1995). But there are examples where this adaptive and discriminatory feature of memory actually seems counter-intuitive. It would not be adaptive for an expert to forget his or her facts about their field of expertise (a problem highlighted by research into the fan effect), or information that is central to a concept or any well-known knowledge. How could individuals function if recalling a well-known fact resulted in the inhibition of another well-known and highly related item (e.g., retrieving 'chairs have legs' inhibits 'chairs have arms')?

This conundrum led M.C. Anderson and McCulloch (1999) to wonder how facilitation and inhibition functions in memory without disrupting the stability of complex knowledge structures. This thinking is not just based on what seems intuitively right, as it has a precedent in retrieval competition, whereby participants are encouraged to form their own associations between competitors. This process of forming connections between related but competing items is called '*integration*' (E.E. Smith, Adams & Schorr, 1978). The self-generation of connections between competitors has been found to reduce retroactive and proactive interference effects (e.g., Postman, 1964), and reduce fan effects (Radvansky & Zacks, 1991; E.E. Smith et al., 1978), and may explain why experts tend not to forget their facts. Radvansky and Zacks (1991) argued that when items are integrated into a larger mental representation (a situation model), the facts cease to compete with each other, while E.E. Smith et al. (1978) similarly believed that introducing a theme helped connect competing items together. Such studies suggest that the difference between experts and non-experts is not the volume of stored knowledge, but rather the greater degree

to which experts integrate new information with old information. Thus, the more thorough integration of similar facts into a single concept by experts helps to reduce, or even eliminate, competition and interference (see also M.D. MacLeod et al., 2003).

As this research suggests that integrating competing information with a concept (i.e., cue) prevents these items creating competition, and thus interfering with the target material, integration within the retrieval practice paradigm may also provide a method for participants to protect themselves from inhibition. Competition could be resolved in this paradigm by encouraging participants to integrate competing items with the target material in order to prevent inhibition from being triggered through the retrieval process. This could be achieved through the encoding of similarities between targets and competitors.

M.C. Anderson and McCulloch (1999) were the first to examine this possibility through instructing participants to integrate each exemplar with each other and to their category cue in a meaningful way (i.e., through finding similarities between items). M.C. Anderson and McCulloch not only found that participants who were explicitly instructed to integrate item failed to exhibit retrieval-induced forgetting, but that participants who naturally integrated items in this manner also failed to show retrieval-induced forgetting.

Similarly, Bäuml and Hartinger (2002) manipulated the degree of relatedness between targets and competing items through the use of categories and sub-categories. More specifically, RP+ and RP- items were either drawn from the same category and sub-category (e.g., tiger and lion are both FOUR LEGGED ANIMALS and PREDATORS), or from the same category but different sub-categories (e.g., tiger and horse are both FOUR LEGGED ANIMALS, but horse is not a predator). Further to these experimentally determined similarities, participants were also instructed to

relate each item to its category and to its sub-category (if it belonged to one). As expected, retrieval-induced forgetting was eliminated when the RP+ and RP- items belonged to the same category and sub-category, but robust findings were found when these items belonged only to the same category.

Similarly, M.C. Anderson et al. (2000b) also found that instructing participants to integrate RP+ and RP- items eliminated retrieval-induced forgetting, and, in fact, RP- items benefited from this increased degree of similarity with the target items. These results have been interpreted within M.C. Anderson et al.'s two-factor pattern suppression model, suggesting that RP- items benefit from sharing a high degree of similarity with the RP+ items, which in turn facilitates their retrieval. Under these retrieval conditions, RP- items are believed to be protected from inhibition due to the loss of competition between these competing items and the target RP+ items. With competition having been resolved through this integration, retrieval-induced forgetting is not triggered. In contrast, when targets and competing items are not highly integrated, competition occurs during retrieval practice and is resolved through the typical inhibition of the RP- items (M.C. Anderson et al., 2000b; Bäuml & Hartinger, 2002).

One such condition where it could be beneficial to protect memories from retrieval-induced forgetting may be information that is personally relevant. For example, we tend not to forget our home address, where we parked the car, or the names of members of our family, nor would it be adaptive for us to do so. Much like an expert who is unlikely to forget highly integrated information from his or her field of expertise, personally relevant information is also likely to be highly integrated, and thus protected from the effects of inhibition. If information that defines us as individuals were susceptible to such inhibitory effects, then our cognitive lives would

be host to a myriad of problems. Not only would we be unable to remember personal information that would allow us to complete everyday tasks, our own self-image of ourselves could become unstable through changes in the facilitation and inhibition of information. In support of this reasoning, Macrae and Roseveare (2002) found that retrieval-induced forgetting effects were eliminated when information was encoded with relevance to the self. In contrast, strong retrieval-induced forgetting effects were found when participants encoded information that was relevant to another person (either a best friend or an unspecified other). Contrary to self-referent information, information about other people, even best friends, will not be subject to the same degree of integration, and thus will be susceptible to inhibition. However, the latter point may be dependent on whether the information tells us something positive about another individual, or something negative. It may not be adaptive to inhibit some negative information (e.g., that the individual is violent), although under some circumstances this may be untrue (e.g., an abused child or beaten wife who is unable to escape the abusive environment, Freyd, 1996). Further to this, some information about others, such as first impressions and out-of-role behaviours may be resistant to inhibition due to the rich information they provide about an individual.

M.D. MacLeod et al. (2003) have also suggested that inhibitory processes may play an important role in regulating mood and self-image. For example, the retrieval of negative memories in clinically depressed patients may inhibit the retrieval of more positive memories, resulting in the maintenance of a depressive episode. Similarly, the inhibition of unpleasant memories about personal failures may help to maintain a positive mood and self-image in non-clinical populations, while the inhibition of memories concerning personal successes may contribute to the unstable self-image

that typifies personality disorders such as borderline personality and narcissistic personality disorder.

The seeds of this possibility can be seen in a study by Amir, Coles, Brigidi and Foa (2001), who found that participants who suffered from generalised social phobia were unable to inhibit negative social information. In contrast, non-anxious control participants displayed the typical pattern of retrieval-induced forgetting, and thus were able to inhibit this negative social information. In the case of the phobic population, the negative social information is likely to be highly integrated into their self-image, thus making this information very difficult to suppress. On the other hand, negative social information is unlikely to be overly integrated into the self-image of non-anxious individuals. This being so, an interesting addition to this study would have been to examine the ability of recovered social phobics to inhibit negative social information. Would this type of information still be self-referential, despite recovery from the anxiety disorder?

Conclusions from Retrieval-induced Forgetting

To summarise, retrieval-induced forgetting has provided a novel approach to studying inhibitory process in unintentional forgetting that has allowed various adaptive properties to be inferred about forgetting. The inhibitory processes underlying retrieval-induced forgetting appear to be flexible and are not constrained by variables such as repeated retrieval, age of memories, or the complexity of the materials. Retrieval-induced forgetting appears to be a form of goal-directed forgetting that allows individuals to fulfil current memorial goals through the inhibition of unwanted but related material. However, it can also have unintended consequences for future cognitive tasks that require those inhibited items. Under such conditions, where

information is unavailable for retrieval, individuals are unable to base their future decisions or behaviours on that information. In situations such as an interview with an eyewitness these individuals may have glaring omissions in their testimony, while individuals under examination conditions may be unable to complete an exam script. Similarly, when we are unable to access information about others we may base our thoughts and behaviours on inappropriate information, such as stereotypical information.

CHAPTER 4

INVESTIGATING THE UPDATING OF MEMORY THROUGH THE
MISINFORMATION EFFECT

The previous chapter has examined recent research into retrieval-induced forgetting which suggests that there may be numerous negative repercussions of the updating process. Not only can information be omitted from memory for an event (e.g., M.D. MacLeod, 2002; Macrae & MacLeod, 1999), but we can also find ourselves relying on inappropriate information in place of inaccessible memories (e.g., Dunn & Spellman, 2003). In a similar area of research, memory suggestibility has previously provided a method for examining memory updating, and more specifically, for examining the negative consequences of forgetting. Despite the memory suggestibility approach providing an ideal method of examining the mechanisms that underlie memory updating the majority of this field has primarily concerned itself with more basic questions regarding the permanency of memory. The current chapter considers various arguments that have been advanced, with reference to the destructive updating and coexistence accounts of memory. Finally, the chapter concludes by considering the role that retrieval inhibition may play in memory suggestibility.

Examining Memory Suggestibility through Leading Questions

After witnessing an event we are sometimes exposed to additional or contradictory information that can influence our memory of that event. This had been investigated using the paired-associate paradigm with word lists, demonstrating that information encountered after an original event can impair memory for that original event

(Chandler & Gargano, 1998; Underwood & Postman, 1960). This effect can also occur in more naturalistic contexts, where the original scene is a complex event and where subsequent information is verbal in nature (e.g., eyewitness memory; E.F. Loftus, 1975; E.F. Loftus & Palmer, 1974; E.F. Loftus & Zanni, 1975; Pezdek, 1977). Memory impairment has also been investigated where the original information and the post-event information appear in the same modality, such as when they are both presented visually (e.g., Chandler, 1989, 1991), or verbally (e.g., Chandler, Gargano & Holt, 2001). Under these eyewitness memory conditions, additional or contradictory information can come from many sources, such as through discussing an incident with each other, with friends and family after the event, and with the police during an interview. For example, information that a witness never originally encountered can be added to their memory of an incident through discussion with another witness. Equally as damaging to the validity of an eyewitness' testimony is exposure to contradictory information. A witness can come to believe a contradictory piece of post-event information to be true for many reasons, such as believing that other witnesses have better memories, pre-conceptions concerning criminal incidents, etc.

The wording of questions can also influence an individual's memory for an event. An eyewitness can be asked questions concerning an incident many times, and from various sources, such as the police at the scene, and at the police station, pre-trial questioning by solicitors, and questioning during a trial. The effects of questioning on memory has been largely investigated using a leading question paradigm and has demonstrated the ease by which memory for the original event can be manipulated (e.g., E.F. Loftus & Palmer, 1974). For example, the question 'About how fast were the cars going when they *smashed* into each other?' resulted in participants estimating

a higher speed for the cars than when 'smashed' was replaced with less graphical words such as 'collided' or 'bumped', or neutral words such as 'contacted' or 'hit'.

The phrasing of a question does not just affect the immediate response to that question, but can continue to impact on memory for an event, and responses to subsequent measures of memory. For example, 'How fast was car A going when it ran the *stop sign*?' assumes that a stop sign was in fact present during the slide sequence. If a stop sign was present, then this question confirms this object's presence and 'points' to where this information may be located in memory for that event. After having received such a question, participants are more likely to say that they saw a 'stop sign' on a later test of memory than participants who received the question 'How fast was car A going when it *turned right*?' (E.F. Loftus, 1975). This effect is also present after a 7-day retention interval (E.F. Loftus & Palmer, 1974).

The phrasing of a question can also add new details to memory for an event (Harris, 1973; E.F. Loftus & Zanni, 1975), and can inform us about how information is integrated into memory. For example, participants were more likely to claim that they had seen a broken headlight in a slide sequence of a car accident if asked the question 'Did you see *the* broken headlight?' compared to the question 'Did you see *a* broken headlight?' The definite article leads participants to assume that the broken headlight was present and to merely confirm its presence, while the use of the indefinite article is a more neutral turn-of-phrase and contains fewer assumptions. In addition, post-event misleading information contained within a question can also impair performance on subsequent memory tests. This style of questioning is quite different from the previous examples, as the answer to these questions is not the focus of attention. Instead, what is of interest is the impact of the misleading information contained within this question on later memory tests. For example, after viewing a

slide sequence containing eight demonstrators, participants who were asked 'Was the leader of the *twelve* demonstrators who entered the classroom a male?' typically estimated more demonstrators on a test one week later than did participants who had received the same question indicating that there were only four demonstrators (E.F. Loftus, 1975, 1977).

The E.F. Loftus Misinformation Paradigm and the Misinformation Effect

This early work examining the impact of leading questions on eyewitness memory raised many interesting questions concerning the original event information after exposure to post-event information that have been examined more closely using a similar paradigm. However, the majority of this work was concerned with the role of language in influencing participant's responses to those questions, and its relevance to the topic of the reliability of eyewitness memory. Thus, this research was primarily concerned with highlighting problems with eyewitness memory and the methods typically employed to extract a statement from such a witness, rather than specifically investigating the effect of additional or false information on the underlying memorial representation of the initial event.

Further to these issues, a criticism of the design of the original leading question paradigm was raised concerning a mis-match between the stimuli used during the study phase and the test phase (E.F. Loftus, Miller & Burns, 1978). In the typical leading question paradigm, the study phase consisted of visual stimuli, while a verbal test was used during the test phase. As the leading questions were also usually verbal in nature, it could be argued that a verbal test would be more likely to aid retrieval of the additional or contradictory information contained within the questions, rather than aid the retrieval of information from the visually presented incident. Thus,

there is an inherent bias within the leading question paradigm that favours the retrieval of information contained within the question, making it difficult to formulate assumptions concerning the memorial representation of the incident.

The most significant change to the leading question paradigm was from a verbal test that required either a 'yes' or 'no' response to a recognition test that used visual stimuli. Thus, the use of visual materials at test matched the use of visual materials during the initial encoding stage and should help address questions that concern the underlying memorial traces. That is, if the original trace exists intact then the use of a visual recognition test should result in the simple matching of the items shown at test to the original trace. In contrast, if the original trace has been altered, then participants will be unable to match the items shown at test with their memorial representation of the initial event.

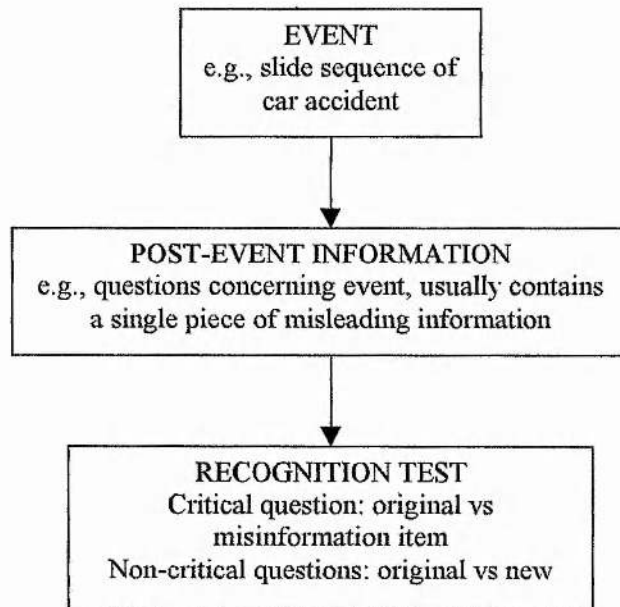
This new paradigm was also specifically interested in the influence of post-event misleading information on later memory performance and what it could tell us about underlying processes in the updating of memory. This paradigm was called the *misinformation paradigm* and was designed to follow the three critical stages that resemble the integration of information into memory (E.F. Loftus & Loftus, 1980). That is, the paradigm has an initial acquisition phase (i.e., encoding of event), a subsequent acquisition phase (integration of post-event information and updating of memory), and a retrieval phase. First, participants view a series of slides depicting an incident (e.g., a car running over a pedestrian), and then receive a post-event questionnaire (e.g., E.F. Loftus et al., 1978; or a post-event narrative, e.g., E.F. Loftus, Donders, Hoffman & Schooler, 1989) about the incident. In the misled condition, participants receive a single piece of misleading information embedded within a question (e.g., Did another car pass the red Datsun while it was stopped at the *stop*

sign?). Typically only one piece of misinformation is introduced in the questionnaire so as not to arouse suspicion (e.g., the stop sign). After completing a distracter task for 20-minutes, participants complete a two-alternative forced-choice recognition task that requires participants to choose the slide they believe appeared in the presentation phase. This recognition test places slides of the original items in direct competition with slides of the erroneous information. For the critical question (i.e., the measure of the misinformation effect), participants have to choose between the original critical item and the misinformation (e.g., yield sign versus stop sign). In this case, participants would be presented with the original slide from the presentation phase showing the Datsun stopped at a yield sign side-by-side with a nearly identical slide showing the Datsun stopped at a stop sign. For the remaining non-critical questions, the original non-critical information is in opposition with a new item, see Figure 17.

This misinformation paradigm is attributed to E.F. Loftus, and paradigms that use recognition tasks where the new item is placed in competition with the misinformation item tend to be referred to as the E.F. Loftus misinformation paradigm or the standard paradigm (e.g., McCloskey & Zaragoza, 1985a). Thus, the study by E.F. Loftus et al. (1978) using this standard paradigm is typically seen as the classic misinformation study. E.F. Loftus et al. compared performance on a recognition test after they had either received information in the questionnaire that was consistent or inconsistent with the slides. Participants who received consistent post-event information chose the original item on a recognition test 75% of the time, while participants who received post-event misinformation only chose the original item 41% of the time. Therefore, when participants are exposed to misinformation they perform at less than chance levels on subsequent tests of memory. When misled participants

choose the misinformation item over the original item at test it is referred to as the *misinformation effect*.

Figure 17: The misinformation paradigm



The misinformation effect has been replicated many times by many different laboratories (e.g., Belli, 1989; Bekerian & Bowers, 1983; Chandler et al., 2001; Christiaansen & Ochalek, 1983; Dodson & Reisberg, 1991; Lindsay & Johnson, 1989a, 1989b; Pirolli & Mitterer, 1984). Not only have stop signs been misremembered as yield signs (and vice versa), but also green cars have been misremembered as blue, hammers as wrenches, and something large and salient such as a barn has been misremembered as being in an empty field. Importantly, as well as alerting us to the danger of misleading information, the misinformation effect also allows us to investigate various important questions concerning memory. How is memory updated? Once information is encoded into long-term memory, is it stored

permanently? Or, can that information be "erased" in a similar manner to computer memory? While the finding that post-event misinformation effect can affect memory for an incident is not in dispute (but see Zaragoza and colleagues, e.g., McCloskey & Zaragoza, 1985a; Zaragoza, McCloskey & Jamis, 1987), the reasons why it does so have been the subject of intense debate.

Boundary Conditions of the Misinformation Effect

There has been a great deal of research that has investigated possible boundary conditions of the misinformation effect. Under what condition are misinformation effects maximised or minimised? Can resistance to misinformation be induced? Are certain groups of individuals more susceptible to the misinformation effect than are others?

One of the most obvious constraints on the misinformation effect is the initial strength of the original trace. A strong memory for the original item will be much more difficult to alter than a weak original trace. One of the easiest ways of creating a strong original trace is to simply re-present the original slide sequence for a second time. Shaughnessy and Mand (1982) did just this and found that if the original slide sequence was re-presented to misled participants then the misinformation effect was abolished.

The strength of the original trace, and the strength of the misinformation trace, can also be altered by varying the length of the retention intervals between the original slide sequence and the post-event information, and between the post-event information and the final test. E.F. Loftus et al. (1978) manipulated the length of the retention interval between the study phase and the post-event questionnaire. The length of this retention interval varied from administering an immediate questionnaire,

to delaying it by 20-minutes, one day, two days, or one week. Under these conditions, the introduction of misleading post-event information had the least impact when the questionnaire was presented either immediately, after 20-minutes, or after one day. However, 60% of misled participants still favoured the misinformation item over the original item. At delays of two-days and one week, up to 80% of misled participants chose the misinformation on a recognition test, which is similar to the level reported for participants who had received entirely consistent post-event information. These results are in marked contrast to participants who received no post-event information of any kind. By the two-day delay, these participants were performing at chance levels.

While these results indicate that the post-event review of an incident can influence subsequent memory performance, the effects either can be beneficial, through the strengthening of the original information, or potentially negative through the integration of false information into memory for that episode. Interestingly, participants who received no post-event information appeared to be guessing after a prolonged delay, but participants who received post-event information (regardless of whether it was consistent or not) performed well above chance. This suggests that by a two-day delay, memory for the incident and the trace of the original target item is very weak. One possibility, therefore, is that participants may be basing the majority of their choices on the post-event questionnaire. This being so, E.F. Loftus et al. (1978) assumed that misinformation has its greatest influence on memory when the original trace has been weakened. Thus, the weaker the trace of the original item, the easier it becomes to alter it. On the other hand, if the trace of the misinformation item has also been weakened, then misled participants can be expected to perform at chance levels. In fact, E.F. Loftus et al. found exactly this when a prolonged delay

occurred between the post-event questionnaire and forced-choice recognition. Under these conditions, misled participants appeared to be guessing at test, suggesting that the long retention interval had resulted in both the memory of the original item from the incident becoming weaker, and the trace of the misinformation item also becoming progressively weaker with time. Thus, when the original trace is relatively weak it is fairly easy to introduce misinformation on that item. However, if both the original trace and the misinformation trace are weak, then participants merely perform at chance levels.

The boundary effect created by manipulating the strength of the original item also implies that resistance to misinformation can be induced by strengthening the original trace, perhaps through additional exposure or through retrieval practice. Obviously, Shaughnessy and Mand's (1982) finding that re-presenting the original information twice, thereby increasing the strength of the original trace, is a simple and effective method of inducing resistance to misinformation. Other ways of inducing resistance that make intuitive sense is through presenting a warning that misleading information is present in the post-event narrative. It can be assumed that presenting misled participants with a warning about possible misleading information being present in the post-event narrative should influence their performance at test. The influence of warnings has a long precedence in research examining factors that affect belief change. If an expert's opinion is attacked, or their credibility undermined, then that expert's persuasive argument has little influence on changing participant's own opinion (e.g., Mills & Harvey, 1972), but only if the attack occurs before the expert has given their persuasive argument (Gruder et al., 1978). Thus, the belief change literature would suggest that forewarnings (either explicit warnings or non-credible sources) presented before the misinformation should prevent that item from

influencing misled participants, but only if that warning occurs before misinformation exposure. If a warning appears after exposure to misinformation, then a misinformation effect should still occur, as the misinformation will already have been integrated into the initial representation of the event held in memory.

Dodd and Bradshaw (1980) found that when misled participants were informed that the post-event information would be from a source with possible intentions to mislead (e.g., the driver that caused an accident), thus making the post-event information biased and low in credibility, misinformation effects did not occur. However, other warning studies have not found that warning provide a constraint on the misinformation effect (Greene, Flynn & Loftus, 1982). While presenting a warning that misinformation may be present in the post-event narrative increased the length of time that misled participants spent reading the narrative; it did not lead to an increase in performance on the original item. That is, increased scrutiny of the post-event narrative did not lead to misled participants favouring the original item at test. Misled participants who received the warning prior to the post-event narrative tended to correctly identify the original item slightly more than misled participants who received the warning subsequent to the narrative. However, presenting a warning at any stage of the experiment tended to result in reduced recognition of the original item and higher misinformation effects compared to a no warning condition. The findings of misinformation effects, despite warnings, suggests that when participants encounter the misinformation item it is spontaneously integrated into memory, immediately updating the memorial representation of the event in memory.

Christiaansen and Ochalek (1983) found the converse. An explicit warning presented prior to the post-event narrative resulted in improved performance on a test for the original item. In addition, even when a warning about misleading information

appeared after participants had read the post-event narrative, a misinformation effect was not found. So, regardless of whether the warning came before or after exposure to misinformation, misled participants demonstrated better memory for the original item than misled participants who were not warned or control participants who were not misled in the first place. Christiaansen and Ochalek explained their results in terms of misled participants being able to review their memory for the original event and "edit out" the misinformation from it.

Misinformation also fails to influence the choices of misled participants at test when it contradicts a central or salient item from the original event. Information that is central to an event or a slide is likely to be fairly salient item resulting in their deep encoding and storage as a strong trace in memory. In contrast, information that is peripheral to an event or slide may not be deeply encoded resulting in a weak trace (or it may not even be encoded). Consistent with this account, Dritsas and Hamilton (1977, discussed in E.F. Loftus, 1979a) found that participants who were misled over a salient or central item were fairly resistant to the misinformation. These participants typically had a high degree of accuracy in choosing the original item at test and ignoring misinformation. On the other hand, participants were easily misled concerning peripheral items. In a similar vein, memory for an event tends to be unaffected by exposure to post-event information that is blatantly untrue. When misinformation contradicts a highly salient and central original item from the slides then misled participants fail to be affected by it (E.F. Loftus, 1979b). In addition, the presence of this blatantly false information colours misled participants perceptions of any other more subtle misinformation that is presented in the same narrative as the blatant misleading information.

Retrieval conditions present at test can also influence the misinformation effect. As already mentioned, the typical test used in the leading question paradigm could be criticised for biasing misled participants at test to rely on the misleading information contained in the questions. This criticism was levelled at the leading question paradigm because the leading questions were either written or verbal in nature and the test that was typically used was also written or verbal. E.F. Loftus et al. (1978) suggested that having a written test may be a better match to the written questions than to the visual slide sequence containing the original information. Thus, the retrieval conditions at test were a better match for retrieving the misleading information than retrieving the original item. The typical misinformation paradigm attempted to remove this bias by changing the written test to a visual forced-choice test that should encourage misled participants to retrieve the original item. A visual test should provide more retrieval cues to the original item by being a better retrieval match. Therefore, if the misinformation effect still occurs in spite of the more favourable retrieval conditions, it could be argued that a retrieval failure account of the misinformation effect would be inadequate.

Despite the retrieval match between the original item and test, retrieval conditions at test have still been shown to provide an important boundary condition to the production of misinformation effects. The notion that forgetting (and remembering) is heavily cue-dependent has precedence in the encoding specificity principle put forward by Tulving (e.g., Tulving & Thompson, 1973), and can be applied to the misinformation effect. Bekerian and colleagues have demonstrated that when retrieval conditions at test are sufficiently strong to reinstate the retrieval conditions present at the encoding of the original item then the original item is chosen at test. In contrast, if the retrieval conditions at test are a better match for the retrieval

conditions present at the encoding of the misinformation item then the misinformation is more likely to be chosen at test (Abeles & Morton, 1999; Bekerian & Bowers, 1983; Morton, Hammersley & Bekerian, 1985). These kinds of context-reinstatement effects have also been used with some success in the cognitive interview technique.

When is Misinformation Integrated into Memory for an Event?

A major question of interest concerning the misinformation effect is *when* the misinformation item is integrated into an individual's memory for an event. Is the misinformation spontaneously integrated into memory when participants are exposed to misleading information, or does the misinformation item become integrated into event memory during the forced-choice recognition test when participants are asked to remember the original event? Considering this latter question, if the misinformation is integrated into memory at test, is there a conflict between the original item and the misinformation item that must be resolved before misled participants can make a choice at test?

These questions were initially investigated by E.F. Loftus (1979b) using blatant and subtle misinformation. E.F. Loftus reasoned that, if the integration of the misinformation into event memory was occurring relatively instantaneously after exposure to misleading post-event information, then blatant misinformation will only have a "spill-over effect" if it is presented along side more subtle misinformation. That is, if blatant misinformation causes misled participants to more closely scrutinise their memories for an original event, then misled participants may become more resistant to other subtler misinformation presented in the same post-event question. If the misinformation item is integrated into event memory at test, when participants are asked to recall the original event, misled participants are likely be more careful about

relying on their memory for the original event and not rely on any information that came from the post-event questions. Under these conditions, even when blatant misinformation is presented much later than the subtle misinformation, the subtle misinformation items will not be integrated into memory until test. Thus, the resistance to misinformation that can be created by blatant misinformation can still spill over and affect the integration of the subtle misinformation even if the blatant misinformation was perceived after the more subtle items. On the other hand, if misled participants are exposed to subtler misinformation first then there should be no spill over effects from the later encoding of blatant misinformation because the subtle misleading information has already been encoded.

E.F. Loftus (1979b) found evidence consistent with the misinformation being integrated rapidly with memory for an original event. When subtle misinformation was encountered in the same post-event question as the blatant misinformation, misled participants never accepted any of the misleading items. Most importantly, when the subtle misinformation occurred prior to the presentation of blatant misinformation (i.e., by one day), misled participants appeared to accept these more subtle suggestions. Under these conditions, misled participants still rejected the blatant misinformation, but chose the subtler misinformation item at test. This finding suggests that the subtle misleading information was integrated into memory for the original event soon after its presentation. Thus, when the blatant misinformation was presented it was too late for misled participants to scrutinise their memory for the event and try and "edit out" the subtle misleading items.

It could be argued that the introduction of blatant misinformation is not really an adequate measure of whether the misinformation is integrated into memory upon its introduction, or whether it is integrated during the test phase. The use of blatant

misinformation is more appropriate for addressing experimental hypotheses that concern how easily manipulated memory is, or whether misled participants are responding to demand characteristic (e.g., the experimenter prepared the post-event information and so must know what is contained in the slides despite this post-event information obviously contradicting the slides), or the effects of warning on the misinformation effect (e.g., blatant misinformation could be considered a warning that the post-event information is not to be trusted).

Discrepancy detection work provides another more indirect measure of when misinformation is integrated into memory for an event. Tousignant, Hall and Loftus (1986) considered that misled participants who were given more time to detect the discrepancies between the post-event information and the slides may be more resistant to integrating the misinformation into their memory for the event compared to misled participants who were not given sufficient time to detect these discrepancies. Therefore, if the integration of misinformation occurs at its introduction during the post-event information, misled participants who are induced to scrutinise this post-event information may detect that the misinformation item contradicts information from the original event, resulting in the misinformation not being integrated into memory. In contrast, misled participants who are not encouraged to scrutinise the post-event information, may be less likely to detect the inaccuracies, resulting in the integration of the misinformation into memory for the event. However, should the assimilation of misinformation not occur at the time of its introduction during the post-event information phase, but instead occur at test when participants are recalling the event, then any additional time to scrutinise the post-event information should have no effect.

Tousignant et al. (1986) encouraged misled participants to detect the discrepancies between the post-event information and the original slide sequence by instructing misled participants to read the post-event information either slowly or quickly. By encouraging misled participants to read the information more slowly, it gives them more opportunity to recall the original event and compare the post-event information with it. Tousignant et al. found that misled participants who were instructed to read the post-event narrative slowly were more resistant to misinformation, while misled participants instructed to read the post-event information quickly were susceptible to the misinformation. That is, participants who read the post-event narratives slowly had more opportunity to scrutinise their memory of the event. Having detected discrepancies between their memory of the event and the post-event narrative, these misled participants did not integrate the misinformation into their memory for the event. On the other hand, misled participants who read the narrative quickly did not have as great an opportunity to scrutinise the narrative for errors, resulting in the rapid assimilation of the misinformation into memory. This pattern of results was also found for participants who were naturally slow or fast readers suggesting that some individuals are more susceptible to misinformation than other individuals.

One technique that could be considered a more direct and appropriate method of addressing when misinformation is integrated into event memory would be to measure the time taken to make a choice at test. Not only are reaction times seen as a useful method for measuring when information is processed (Howell, 1973), but this technique has already been used with varying success in examining whether judgements are made at comprehension or during final test (e.g., Hintzman, 1976; Voss, Vereb & Bisanz, 1975). Measuring how fast misled participants are to choose

an item at test can inform us about whether misled participants complete the critical question with a memory for both the original item and the misinformation item. That is, if misled participants are slow to choose an item at test, it not only suggests that they have a memory for both the original item and the misinformation item, but it also suggests that the misinformation item is not rapidly integrated into memory for the event. On the other hand, if misled participants respond quickly on the critical question, it would suggest that any conflict between the original item and the misinformation item has been resolved before the test phase. Thus, misled participants only remember one of the items, and if it is the misinformation item, it is likely to have been integrated into memory for the original event soon after its presentation.

Cole and Loftus (1979) were the first to examine reaction times at test after exposure to misinformation using a Yes/No test that required participants to confirm whether an item had occurred in the study phase or not. While Cole and Loftus found that misled participants tended to be slightly faster to say that the misinformation has been present in the study phase than to confirm that an original item had come from the study phase, no significant misinformation effect was actually found. There was only a reduction of 8% in misled participants who chose the original item at test compared with control participants who received consistent post-event information. Thus, while misled participants are equally as fast to choose an item at test, the non-significant misinformation effect makes it difficult to interpret the faster reaction times in favour of the misinformation item being integrated into memory at its introduction. Any conflict resolution between the original item and the misinformation item has obviously been resolved, as indicated by the fast reaction

times, but this conflict resolution has not favoured the acceptance and integration of the misinformation item.

E.F. Loftus et al. (1989) discovered that misled participants were actually *faster* to choose the misinformation item on the critical question at test than they were to choose an original item on a non-critical question. This suggests that misled participants who chose the misinformation item on the forced-choice recognition test only remembered the misinformation item on reaching the test phase. That is, any conflict between memories for the original item and the misinformation item may have been resolved before participants reached the test phase. The finding of fast responses in choosing the misinformation item strongly suggests that misinformation is integrated into memory for an event before the test phase, and likely soon after its encoding.

The various findings from indirect measures of misinformation integration, such as blatant misinformation (E.F. Loftus, 1979b), and discrepancy detection (Tousignant et al., 1986), as well as the direct measure of reaction times (Cole & Loftus, 1979; E.F. Loftus et al., 1989) strongly suggest that any conflict between the original item and misinformation is resolved before the test. The results from these studies are consistent with the integration of misinformation into memory for an event occurring soon after exposure to misleading information.

Interpreting the Misinformation Effect: Trace Alteration or Trace Coexistence?

The design of this misinformation paradigm is quite similar to that of the A-B, A-D paired-associate procedure that was used during the classic interference era, and the misinformation effect can be viewed as a form of retroactive interference. That is, the learning of the new misinformation item during an interpolated task (e.g.,

questionnaire, post-event narrative) interferes with the ability to recall the original target item. In terms of the misinformation paradigm, the A stimulus represents the incident, while the B response represents the original target item that is associated with the incident. The D response represents the misinformation item, and if it is assumed that the misinformation does effect memory (e.g., E.F. Loftus et al., 1978; Bekerian & Bowers, 1983), it creates a retroactive interference effect, resulting in impaired memory for the original target item.

In a similar manner to the retroactive interference effect, the misinformation effect has been subject to the same arguments concerning the fate of the original item as the B response was in the A-B, A-D paradigm. The majority of research has argued either that the misinformation effect is the result of a storage failure, whereby the underlying trace of the original item is permanently altered, erased, or weakened through exposure to the misinformation (e.g., E.F. Loftus, 1975, 1977; E.F. Loftus et al., 1989; E.F. Loftus et al., 1978), or is the result of retrieval failures (e.g., Bekerian & Bowers, 1983; Chandler & Gargano, 1995, 1998; Morton et al., 1985). Thus, while the A-B, A-D paradigm could be criticised for having little external validity due to its use of word lists, the misinformation paradigm demonstrates that interference effects can generalise to materials other than paired-associated, and more importantly, perhaps to everyday memory.

Trace Alteration: Destructive Updating

The earliest interpretation of the misinformation effect was that the misleading information erased the original trace. At its most extreme, this destructive updating hypothesis proposes that the original trace is completely and permanently destroyed or erased through a destructive updating mechanism. This destructive updating

mechanism was an essential feature of E.F. Loftus' theory of how information was integrated into memory as she believed that there could only ever be one memorial representation of an event stored in memory at any one time (E.F. Loftus, 1979b). Thus, if additional or contradictory information about a perceived event was experienced then the stored event was updated in memory. This updating occurred through the erasure of the out-of-date or contradictory information, and this information was replaced by the new or correct information. As computers erase old information when their memory is updated, the destructive updating account, and its use of terms such as 'permanent erasure' or 'trace destruction' is very reminiscent of the computer analogy of the brain. Despite the precedence of destructive updating in computer science, few specific details of how this mechanism would manifest itself have ever been advanced. Does this erasure occur before the original memory has had time to consolidate? How would a destructive updating mechanism know what information to erase and what to preserve? Are all memory traces placed at risk of being erased when newer information or contradictory information is encountered?

The assumption that the original item has been permanently altered also has implications for how one would go about recovering that item. As the trace corresponding to the original item is believed to have been destroyed, the only way to return that original item back to the memorial representation of an event is to re-alter the misinformation back to the original item. This means that misled participants would have to re-encode the original item in order for it to destroy the trace of the misinformation item. Consistent with this view, Shaughnessy and Mand (1982) found that if misled participants were re-exposed to the original item through viewing the slide sequence again after post-event questioning, the original item was chosen at a level similar to that of neutral control information, and nearly as high as consistent

information. This result could be interpreted as indicating that the misinformation item altered the trace of the original item, and then re-exposure to the original item led to the original item to alter the misinformation trace back again.

In order to support the hypothesis that the original trace has been compromised, either through erasure, weakening, or blending, every effort must be made to demonstrate that the original item is not present in memory. The majority of studies that provide support for the assumption of memory alteration come from failed attempts to recover the original item after exposure to misinformation. Various techniques have been used in an attempt to recover the original event memory, such as using blatant misinformation, second-guess techniques, incentives and hypnosis.

The use of blatant misinformation is believed to encourage participants to scrutinise their memories, to reject contradictory information, and not to trust the source of the misinformation. E.F. Loftus (1979b) discovered that, overall, participants were likely to detect the presence of blatantly false information and reject all subtle misinformation related to that source. That is, when subtler misinformation appeared along side the blatant misinformation, such as in the same post-event question, then misled participants tended not to choose any of these misleading item at test. This may be due to misled participants rejecting the post-event information as a reliable source to base their choices on at test. However, when the introduction of blatant misinformation was delayed, so that the subtle misinformation appeared one day before the blatant misinformation, misled participants were likely to incorporate the previously presented subtle misinformation into their memory for the event, even though they rejected the blatant misinformation at test. E.F. Loftus interpreted these results as evidence for the subtle misinformation being integrated into event memory immediately, or soon after, misled participants are exposed to it, rather than

participants holding both the original item and the misinformation in memory until test where they make a decision between them based on which trace is the strongest. This being so, misled participants' memory for the event is updated fairly quickly through the erasure of the original item and integration of the misinformation item. Even when subsequent information suggests that misled participants should not trust any information contained in the post-event information (i.e., blatant misinformation), it is too late for misled participants. They have already integrated the subtle misinformation into their memory for the event. Thus, for misled participants, the memorial representation of the event has already been permanently updated with the subtle misinformation items through the destruction of the original trace. Under these conditions, the only way to recover the original item would be to re-alter memory for the misinformation back to the original item.

E.F. Loftus (1979a) also theorised that if participants have no memory for the original item due to the misinformation over-writing it then, even if participants are given a second chance to choose the correct items at test, they will perform at chance levels. If participants have even a fragment of the original item in memory, they should choose that item at above chance levels. Using a forced-choice recognition task that contained three options, the original item, the misinformation, and a novel item, E.F. Loftus had participants who failed to choose the original item make a second choice. The majority of the misled participants failed to choose the original items on their first attempt, however, they also failed to choose the correct item above chance levels when given a second opportunity. E.F. Loftus interpreted this result as evidence that misled participants had no trace of the original item in memory because if they did, when given a second choice between the original item and an item that they had never seen before, they would have chosen the original item. As they failed

to do so, it suggests that misled participants treated the original item as if it was also an item that they had never seen before.

E.F. Loftus (1979a) also explored a possible social explanation for why participants fail to retrieve the original item when prompted to do so – misled participants may be insufficiently motivated to do so. In separate experiments using monetary and verbal incentives, however, E.F. Loftus failed to find any evidence that the original item was still present in the memories of participants who had been exposed to misinformation. Finally, hypnosis has been used as a technique to recover the original item from the memories of misled participants. Participants placed in a hypnotic state, however, have also been unable to recall the original item when encouraged to do so (Sheehan, Grigg & McCann, 1984).

Of course, while these studies may all be consistent with the hypothesis that the original item has been erased by the misinformation through a destructive updating mechanism, it can be argued that E.F. Loftus and colleagues have simply not used a sufficiently strong manipulation or retrieval method in order to recover the original item. This remains perhaps the greatest remaining thorn in the side of the destructive updating hypothesis. Unfortunately, unless the state of the original trace can be examined at a neural level, the original item can never be shown to have been erased by the misinformation.

Trace Coexistence: I. Retrieval Accessibility

An alternative to the notion that memory is destructively updated is the theory that, once information is encoded into long-term memory, it permanently resides in memory. This theory that memories 'coexist' suggests that forgetting is more likely to be due to retrieval failures, such as an inappropriate or ineffective retrieval cue, or

due to participants mistaking the misleading item as having originated from the original event, rather than being due to the destruction of memory traces. This coexistence of memorial traces also has an important adaptive advantage over the destructive updating hypothesis. As the destructive updating hypothesis proposes that old or out-of-date information is erased by newer information, the only way to recover that erased information is to re-encode it. In contrast, as the coexistence hypothesis proposes that information is permanently stored in long-term memory, then old or out-of-date information can be retrieved through the use of the correct retrieval strategies, or through paying close attention to the source of certain memories.

The finding that both the original item and the misinformation item coexist in memory has been replicated many times (e.g., Bekerian & Bowers, 1983; Chandler & Gargano, 1998; Christiaansen & Ochalek, 1983; Lindsay & Johnson, 1989a, 1989b; Pirolli & Mitterer, 1984). Typically, retrieval conditions at test are manipulated in order for the original item to be successfully retrieved. This dependence on retrieval conditions has led to the supporters of the coexistence hypothesis interpreting the misinformation effect as being due to either a mis-matching of encoding and retrieval cues (e.g., Morton et al., 1985), the retrieval access of misinformation 'blocking' the retrieval of the original item (Chandler, 1991), or the misattribution of the misinformation to the original event (Lindsay & Johnson, 1989a). However, there are many studies that merely replicate that the original item still continues to reside in memory after the encoding of the misinformation without adding insight into the memorial processes that may underlie this effect (e.g., Christiaansen & Ochalek, 1983; Pirolli & Mitterer, 1984). These studies merely corroborate the idea that the destructive updating hypothesis of the misinformation effect is inadequate to account for these findings of trace coexistence. For example, Christiaansen and Ochalek

(1983) provide evidence that the original item remains unaltered in memory after the introduction of post-event information.

On the other hand, many of the assumptions of the coexistence hypothesis concern the conditions that are present during the encoding and retrieval of information. Tulving's encoding specificity principle directly influences these assumptions (Thompson & Tulving, 1970; Tulving & Osler, 1968; Tulving & Thompson, 1973). The encoding specificity theory proposes that every memory that is encoded into long-term memory is encoded within a context. The memory and the related contextual information that is encoded alongside it form a 'unique trace' (Wiseman & Tulving, 1976). Information that is stored with the memory can include external contextual information such as the time of the memory, the location of the memory, texture, modality (e.g., verbal, pictorial), smell, etc., as well as internal contextual information, such as an individual's mood, feelings, or thoughts, etc. This contextual information can act as retrieval cues with their presence within the retrieval environment aiding recall of related memories, and their absence hindering the retrieval of related memories. Thus, the success of retrieving that stored information will depend on the number of contextual cues present at retrieval that match with those contextual features that were encoded with the memory. The more contextual retrieval cues present the easier and more successful the retrieval process will be. Thus, Tulving proposes that memory retrieval is *cue dependent* and retrieval failures are due to *cue dependent forgetting* (Tulving & Psotka, 1971). That is, information can be available in memory but not currently accessible (Tulving & Pearlstone, 1966). For example, in a memory experiment where participants are being asked to remember a word list, in addition to encoding the word list, participants also encode contextual information concerning the room that the experiment is conducted in, the

time of day, the mood of the individual, etc. When asked to retrieve that word list, participants are likely to be more successful if asked to recall the words in the same room that they were encoded in, rather than having to try and recall the list in a second room. However, while changes in environmental context during the encoding and retrieval of the original event and the post-event information can affect performance at test (e.g., Lindsay, 1990) there is actually very little support for the idea (e.g., Bonto & Payne, 1991).

A more successful application of the encoding specificity principle has been to the reinstatement of thematic information encoded at study. Bekerian and Bowers (1983) proposed that the misinformation effects found with the typical misinformation paradigm may be due to a mis-match between encoding and retrieval cues. During the original encoding phase, participants watch a slide sequence that shows a car accident occurring in a forward temporal order, from start to finish. These slides are shown in sequence, creating "themes", such as the incident, setting, and context that are all connected to each other. This "thematic information" allows a participant to understand the general global details as well as the finer details of the event. On the other hand, if the incident was viewed out of sequence, there may be difficulty, or a complete inability, to understand what was observed. While the slides are usually viewed in order, the items that are tested in the recognition task are typically tested in a random order. This randomisation of the test slides may minimise the number of thematic retrieval cues that participants are able to access and use to access the original memory. As few of these thematic cues are available at test, participants may come to rely on their most recent memory concerning the target event, specifically the post-event information that contains the misleading information.

Bekerian and Bowers (1983) hypothesised that reinstating the thematic features from the study phase during the test phase should abolish the misinformation effect. Reinstating contextual cues should allow participants to use the same thematic information that they encoded in the slides as retrieval cues during the recognition test. This should allow participants to have much easier access to their memory of the original event, due to a greater matching of encoding and retrieval cues, than their memory of the post-event information. The results, in general, support this hypothesis. Misled participants were much more likely to choose the misinformation item on a recognition test when the test slides were presented in a random order, than when they were presented in a sequential order. In fact, misled participants who were administered a sequential test performed at the same levels as did other participants who received the same test but who had not been misled. Thus, the original and misinformation traces appear to coexist in memory, a finding inconsistent with the destructive updating account of memory.

An interesting but ignored finding concerns performance by the control participants who received no misleading post-event information. While the order of test slides had no effect on performance for non-critical item, control participants performed better on the critical item under random testing conditions (6% error), than under sequential testing conditions (15% error). Bekerian and Bowers (1983) seem to have overlooked this finding and fail to account for why random testing did not also affect performance for non-critical items or control participants. If random testing disrupts thematic retrieval cues, then it is not only likely to impair the retrieval of information from the original event, but also from the sequentially ordered post-event information as well. Therefore, there should have also been a drop in performance for control participants in the random testing condition on both the critical and non-

critical items. However, this appears not to have been the case, with performance on the critical item for control participants greater in the random testing condition (6% error) than in the sequential testing condition (15% error).

Expanding on Bekerian and Bowers (1983) assumption that the misinformation effect is due to retrieval failures, Morton et al. (1985) proposed that memory for an event was organised so that the original and misinformation items are stored separately and independently in memory. Each item encoded from an event is stored as individual units called 'Records' that remain unconnected to each other. Each of these Records has its own set of retrieval cues and retrieval routes, called 'Headers'. Unfortunately, the information contained in a Header is unavailable to conscious inspection, and so an individual must use a 'Description' in order to match a Header to a Record. Descriptions are normally defined by a task, such as a question, which provides information for matching Headers to Records.

The Headed Records account of the misinformation effect assumes that the information contained within the recognition test influences the formation of the Description. This, in turn, biases the matching of Headers to Records formed from the post-event information. In the context of a misinformation paradigm, this means that the information contained within the recognition test, such as the random sequence of item, forms a Description that searches relevant Headers in parallel. This Description is able to access both the Header of the original item and the Header of the misinformation item. However, the Description is most likely to access the Header of the misinformation as this Header is more recent. In addition, the Header of the original item contains information concerning the sequential nature of the original event, sequential information which is absent from the Description being used to search the Records. With the access of the misinformation Header, the Record for

the misinformation is retrieved, and participants choose the misinformation item on the recognition test.

While this Headed Record model may be able to account for some misinformation effects, it is unclear why the sequential information that would also be stored in the Record and Header for the misinformation effect does not also impair performance at test. The original event was not the only event that ran in a sequential order as the post-event information also ran sequentially. In addition, as the Description contains information about the visual nature of slides in the test, should the Description not be a better match to the Header for the original item, which also contains visual information, rather than the verbal information contained within the Header for the misinformation? Thus, other than the Record corresponding to the misinformation having been formed closer to the test than the Record for the original item, it is unclear how information contained within the Description is a better match to the Header for the misinformation rather than the original item.

Kroll, Ogawa and Nieters (1988) also provide additional evidence in support of a retrieval failure account of eyewitness memory errors. After completing an interpolated test, participants were presented with the original slides either in a random order, or in a sequential order, and then completed a final test. Participants who were presented with the second set of slides in sequential order were more likely to correct any mistakes that had been made on the initial test than participants who were presented with the slides in a random order. Thus, the second set of slides presented in sequential order may have reinstated any forgotten thematic cues needed in order to retrieve original event information. In contrast, when the slides were presented in a random order, participants were unlikely to have been able to reinstate those thematic cues that would have aided in the retrieval of the original event

information. However, reinstating thematic cues does not always abolish the misinformation effect. Significant misinformation effects have been found with sequential tests (Bowers & Bekerian, 1984; McCloskey & Zaragoza, 1985a), although it remains unclear why sequential tests sometimes eliminate the misinformation effect but under other conditions it does not. Bowers and Bekerian (1984) have noted that reinstating retrieval cues from the original event is sometimes insufficient to access the original item. The retrieval conditions set up during the introduction of the post-event information also determines whether participants will choose the original item or not at test. When the post-event questions are presented in a sequential order, the misinformation effect appears regardless of the test. With a sequential test and questionnaire, the retrieval cues at test may provide access to both the original item and the misinformation item. However, as the misinformation was encountered more recently, the more recent memory is retrieved, resulting in a misinformation effect (Morton et al., 1985). On the other hand, no misinformation effect occurs if a sequential test is presented subsequent to a random questionnaire. Bowers and Bekerian suggest that the random questionnaire disrupts thematic cues that would normally be set up by a sequential questionnaire, resulting in the retrieval cues from the sequential test providing access to the original item.

Trace Coexistence: II. A Discrimination Process

Another set of studies that support the coexistence hypothesis appears to be influenced by assumptions from the classical interference era and place the cause of the misinformation effect as a problem in the retrieval process. However, some of these studies differ from the encoding specificity principle (e.g., Chandler, 1989, 1991, 1993; Chandler & Gargano, 1998), while others provide some support for it

(e.g., Chandler et al., 2001). Many of these studies are very different from typical misinformation paradigms. There are no eyewitness events, or post-event narratives, and they tend to resemble retroactive interference paradigms. However, these studies are directly relevant to the alterations versus coexistence of traces debate, and these tightly controlled studies provide a strong theoretical backbone to the coexistence hypothesis.

The mis-match of encoding and retrieval cues that is assumed by encoding specificity is not the only reason why post-event information can be retrieved in place of an original item. Recognition tests that remove the post-event information as an option and replace it with a novel item should increase the number of retrieval cues that specifically match the original item. Thus, when the original item is in competition with a never seen before item, encoding specificity would predict that the original item should be chosen because the test provides sufficient perceptual and contextual retrieval cues to access the original item. However, this has been shown not to be the case. Even when the retrieval cues present at recognition favour the retrieval of the original item, participants who have been exposed to post-event information tend to perform more poorly than do control participants (Chandler, 1989, 1991; Chandler & Gargano, 1998). This suggests the presence of other retrieval process, such as the retrieval access of the competing post-event trace (Chandler, 1991; 1993; Chandler et al., 2001; Windschitl, 1996), and the failure of the original trace and post-event trace to be discriminated at retrieval (Chandler, 1989, 1991; Chandler & Gargano, 1998).

The presence of these other retrieval processes has been demonstrated with longer retention intervals. Chandler and Gargano (1998) have suggested the presence of a discrimination process and a blocking process that operates at retrieval. Forced-

choice recognition tests may be especially vulnerable to either a failure to discriminate the two traces, or to strong competing items blocking retrieval of weaker items. Which of these processes plays a primary, or exclusive role, appears to be dependent on the type of stimuli used. While a blocking process is thought to play a role in controlling the retrieval of familiar stimuli, a discrimination process is thought to control the retrieval of unfamiliar stimuli (Chandler & Gargano, 1998). Both of these processes have been examined through manipulating the length of retention intervals, and by varying when the post-event information is presented within that interval. Retroactive interference from post-event information typically decreases over increasing retention intervals, with interference decreasing at intervals as short as 15 minutes with paired-associates (Chandler, 1993), and being completely abolished at 48 hours with pictures (Chandler, 1991). This reduction in the interfering effect of post-event information may be due to the retrieval accessibility of post-event information at the time of test. If the recognition test provides retrieval cues that match the post-event information (e.g., the post-event item is an option on the recognition test), then both the post-event trace and the original trace are likely to be accessed by the retrieval cue, resulting in the post-event trace interfering with the original trace (Chandler, 1993). When both traces are accessed in this manner, it may become difficult to discriminate these traces.

This difficulty in discriminating between the original and post-event trace can occur for various reasons. The discrimination process is likely to fail when the original and post-event trace are highly similar, such as when they share perceptual, contextual and temporal cues (see also Pezdek, 1977). In contrast, these traces may be easier to discriminate when the two traces are more dissimilar and share fewer cues. Under these retrieval conditions, retroactive interference effects are absent and

the original trace is easily retrieved (Chandler & Gargano, 1995, 1998). The discrimination process may also fail if the post-event trace is made much more accessible than the original trace. The post-event trace can be strengthened by presenting the post-event information at the end of a long retention interval and just prior to test. Under these conditions, the post-event trace is far more accessible and interferes retroactively with the original trace (Belli, Windschitl, McCarthy & Winfrey, 1992; Chandler, 1993; Chandler et al., 2001). Conversely, increasing the retention interval after the presentation of post-event information, or presenting the post-event information at the beginning of a fairly long retention interval, reduces the retrieval accessibility of the post-event trace (Chandler, 1993; Windschitl, 1996).

Trace Coexistence: III. A Blocking Process

Not all of the findings by Chandler and colleagues findings can be accommodated by a simple trace coexistence theory, such as trace competition or retrieval failure explanation (Chandler, 1991; Chandler & Gargano, 1998). For example, as retroactive interference effects dissipate over longer retention intervals, proactive interference effects increase (Postman, 1971). However, while Chandler (1991) has demonstrated that retroactive interference with similar pictures does decrease over a 48-hour delay, proactive interference effects are completely absent (see also Belli, Lindsay, Gales & McCarthy, 1994). This absence of proactive interference is contrary to the simple coexistence account of traces typically employed to describe misinformation effects. Both the original trace and the post-event trace should have competed with each other regardless of the presentation order of these items. Thus, a simple retrieval failure or retrieval competition explanation of misinformation effects is insufficient to account for this finding. These studies that find that misinformation

effects still occur even when misleading information appears before the original event, strongly suggests that memory is not updated through the destruction of information already stored in memory.

Chandler and Gargano (1998) suggest a role for a blocking process operating at retrieval. This blocking process is only activated when stimuli are highly primed, such as with items that are rehearsed, or familiar information. Thus, blocking would only play a role with information that was already integrated into long-term memory (e.g., word pairs), rather than unfamiliar scenes (e.g., never seen before nature pictures). Blocking predicts that post-event word pairs are more accessible at retrieval than the original word pair. Post-event word pairs should be higher in retrieval accessibility because they have occurred more recently than the original word pairs. Thus, more recent word pairs should be stronger in memory and therefore create more interference.

One way of increasing the strength of competitors is to present post-event word pairs at test rather than immediately after the presentation of the original word pairs. Recent competing items will be stronger and thus more likely to be accessed by retrieval cues than the weaker original items. Strong competitors are also more likely to block retrieval access to the weaker original word pairs (Chandler & Gargano, 1998). These retrieval blocks explain the misinformation effect as being due to the misinformation blocking the retrieval of the original item. Thus, as the misinformation item was encountered more recently than the original item the misleading item is more likely to be accessed at retrieval than the original item. Once the misleading item 'yield sign' has been retrieved it will block the retrieval of the original item 'stop sign' (Chandler et al., 2001). Support for blocking can also be found without having to resort to long retention intervals. Schooler, Foster and Loftus

(1988) found that forcing participants to choose between two incorrect items from the post-event information on an interpolated test resulted in misled participants performing more poorly on a subsequent recognition test where the misinformation was not an option. In typical misinformation paradigms, participants may read the post-event information without paying a great deal of attention to it. When forced to choose an incorrect item from the post-event information on a test, the act of doing so may have increased the accessibility of the information contained in the narrative. When given a choice between the original item and a novel item on the final recognition test, participants previous retrieval of post-event information may have blocked access to information contained within the original event.

There are some difficulties with the blocking hypothesis, however. Misinformation effects have been found when the misinformation was presented two days before test when presumably the misleading item was not overly strong (Ceci, Ross & Toglia, 1987; Toglia, Ross, Ceci & Hembrooke, 1992). However, these retroactive interference effects with weaker competing items do not fully discount the notion of a blocking process. Despite the misinformation not being in a particularly strong retrieval position, these items were presented a day after the original items, and so the post-event information was still stronger than the original event information. However, more problematic for the blocking hypothesis is the finding that increasing the accessibility of the misinformation through interpolated tests (Schooler et al., 1988) does not always result in misinformation effects. Interpolated tests containing post-event information should increase retrieval access to the post-event information on subsequent tests. Having increased accessibility to the misinformation it should block retrieval access to the original event. However, Belli (1993) found that presenting a standard recognition test (i.e., original item versus misinformation)

during the retention interval had no impact on performance in a later recognition test were the misinformation item was not an option (i.e., original item versus novel item). Thus, increasing the accessibility of the post-event information through its prior retrieval does not necessarily result in the misinformation becoming more accessible and blocking retrieval access to the original event. It remains unclear under what retrieval conditions a blocking process would be elicited. Is blocking only triggered under certain conditions, such as with long retention intervals where a degree of forgetting from the original event has already occurred in order for the post-event information to becoming greatly more accessible? Or does the blocking process generalise to any situation where the post-event information is stronger and more accessible than the original event?

Alternatively, it has been suggested that as the post-event information is presented more recently than the original item it may determine the type of retrieval cues that are available at test (referred to as the 'cue-change' hypothesis, Chandler & Gargano, 1995). For example, if the post-event information is presented more recently than the original item (e.g., on different days), then the post-event item may change the type of retrieval cues that are available. If the post-event information was encountered on the same day as the test then there may be more contextual cues present during the test that are a better match to the post-event item than to the original item. The post-event item is most likely to determine retrieval cues when a long delay has occurred between the original event and the presentation of the post-event information. Under these conditions, participants may find it difficult to recall the original event, and rely on the recently encountered post-event information to generate retrieval cues. On the other hand, if the post-event information has not been encountered recently, then participants will not be able to rely on this source for

generating retrieval cues. Thus, there will be fewer retrieval cues available that access the post-event item, and so it will be easier for an individual to reinstate the context that would facilitate the retrieval of the original item (Chandler & Gargano, 1995; Chandler et al., 2001).

More generally, these studies provide strong evidence against the destructive updating hypothesis. As retention intervals increase, the retroactive interference effect decreases in size (Chandler, 1993), and disappears at long intervals (e.g., 48 hours, Chandler, 1991). This finding (i.e., that the retrieval availability of the original item increases as retroactive interference dissipates) suggests that the original item has neither been erased nor altered, but remains in tact. Interference with the retrieval of the original item also appears to be dependent on the post-event information being similar. When the post-event information is dissimilar to the original item then the post-event item creates less interference (Chandler, 1989, 1991, 1993; Chandler & Gargano, 1995, 1998; Chandler et al., 2001). However, this interference effect can be removed by instructing participants to recall only information from the original event and not post-event information. This may be due to the possibility that such generate retrieval cues that are specific and unique to the original item, resulting in their retrieval (Chandler et al., 2001). Chandler et al. (2001) suggest that these interference effects (e.g., misinformation effects) can be avoided by emphasising the importance of retrieval cues that specifically access information contained within a memory for an original event. This can be achieved through encouraging individuals to reinstate contextual cues that are unique to the original event, which may result in the original memory being accessed before memories for related post-event information.

Trace Coexistence: IV. Source Misattribution

However, there is also strong evidence to suggest that misinformation has no effect on the original trace, but is instead due to misled participants mistakenly believing that the misinformation occurred in the original event. This type of research allows the interesting question '*Do participants really believe they saw the misleading item in the original event?*' to be investigated. This approach considers that the misinformation effect is the result of a failure to monitor the source of their memories. The source monitoring account was initially put forwards by Johnson and Lindsay (e.g., Johnson & Raye, 1981; Lindsay & Johnson, 1989a), and suggests that source confusion can occur even if the original item is still present within memory for the event. Thus, this latter point technically makes source monitoring a coexistence explanation as it proposes that misinformation effects can occur despite the original item remaining intact in memory. However, source monitoring differs from the coexistence hypothesis, as it does not assume that misled participants have difficulty in retrieving the original item at test. Source monitoring actually proposes quite the converse. It does not propose that there is any retrieval access problem to the original item, but rather chooses to explain why some misled participants believe that the misinformation item actually occurred in the original event. Thus, this blending of source of memories can provide quite an intuitive explanation of the misinformation effects.

Why might source misattribution errors occur? Misattribution of the source of misinformation can occur because the original item and the misinformation both concern the same event. As the two sources of these items are very similar, the typical eyewitness memory paradigm employed in this type of research fosters the ideal conditions for source misattribution errors to occur. If the original event and the

post-event information were reduced in similarity then participants would be less likely to misattribute the misinformation to the original event (Lindsay, 1990). In addition, the type of recognition tests used in misinformation paradigms may encourage participants to adopt an inappropriate decision making criterion. During this test, for non-critical items, participants are typically asked to discriminate between a visual slide that they have seen before during the visually presented study phase and a new and unfamiliar item that participants have not seen before. This placement of an old and familiar item from the slide alongside a new and unfamiliar item may encourage participants to adopt a decision making process based on familiarity. When misled participants reach the critical comparison between the original item and the misinformation item, misled participants may choose the misinformation item because it seems more familiar to them and they mistakenly believe that item occurred during the slide sequence. The misinformation item could seem more familiar for reasons unrelated to the misinformation over-writing the original item in memory. For example, misled participants who failed to encode the original item may remember that they encountered the misinformation during the experimental episode and think that it must have occurred during the original event, or participants may choose the misinformation item due it being more salient or having been presented more recently.

It should be noted that source monitoring studies tend to use a different paradigm to that typically employed in examinations of the misinformation effect. While typical misinformation studies employ specific pieces of information that contradict items from the original event, source monitoring studies typically use *supplementary* information that is consistent with the general themes of the original event. Thus, source monitoring examines the general *suggestibility* of eyewitness

memory through the integration of additional post-event information, rather than the effects of exposing participants to contradictory post-event information. For example, Zaragoza and Lane (1994) found that misattributing the misleading item to the original event is not an inevitable consequence of being exposed to post-event information. It would appear that participants are more susceptible to suggestions if they are completing a task that requires participants to actively retrieve and reconstruct the original event in their memory at the same time that the suggested detail is being processed. Simply reading a post-event narrative that contained suggested details tended to result in very little source misattribution. Participants who completed tasks containing suggested details with a higher retrieval component, such as unscrambling a narrative, or answering misleading questions, however, were far more likely to misattribute the suggested details to the original event.

Research into source confusion has highlighted Zaragoza and Lane's (1994) finding that mere exposure to a suggested detail is insufficient to cause participants to misattribute that item to the original event. Zaragoza and Koshmider (1989) have also failed to find any evidence for source confusion in the production of misinformation effects in a typical misinformation paradigm, or that considering the source of the misleading item abolishes the misinformation effect. Misled participants did not mistakenly attribute the misleading item to the original event, and correctly identified it as having originated from the post-event narrative. Misled participants were also able to identify the original item as correctly having originated from the slides to the same degree as control participants. However, significantly fewer misled participants failed to recognise that the misleading item was inconsistent with their memory for the event compared to control participants. This means that there was a degree of integration of the misleading item into memory for the event that did not occur with

control participants. Collectively, these findings suggest that misled participants chose the misinformation item despite their awareness that they could not remember seeing that item in the original event. Thus, participants can be aware of the source of their memories, but still favour the misinformation item over the true original item, suggesting that source confusion is not always an explanation of misinformation effects.

As Lindsay and Johnson (1989a) suggested that the misinformation paradigm was likely to be susceptible to source monitoring errors due to the original event and post-event information referring to the same event, Lindsay (1990) investigated whether making these sources more distinct could influence the magnitude of the misinformation effect. A two-day delay was inserted between the original event and the post-event information, thereby increasing the distinctiveness of these two sources in participant's memory, or the original event and post-event information occurred in the same session two-days before test, thereby decreasing their distinctiveness in memory. Lindsay found that increasing the distinctiveness of the two sources of information in memory resulted in the abolition of the misinformation effect. Thus, these participants are likely to have used the temporal distinctiveness of the original event from the post-event information to guide their choices at test. In contrast, when the original event and the post-event information occurred within the same session, a reduction in the temporal distinctiveness of these two sources, a misinformation effect emerged.

Lindsay's (1990) work suggests that source misattributions between the post-event information and the original event will be greater when these sources are made less distinct. Lindsay increased source confusion by decreasing the temporal distinctiveness of the information learned during the original event and that learned

during the post-event information. Similarly, source monitoring would suggest that misled participants who visualise the misleading item should be more susceptible to making source misattribution errors. Visualising the misinformation item should increase its similarity to the visual original event and increase the probability that misled participants will choose this item at test. While research using patterns (Finke, Johnson & Shyi, 1988), and text (Intraub & Hoffman, 1992) suggests that visualising additional post-event information increases source confusion, no studies have been conducted to examine the effects of visualising post-event information in the misinformation paradigm.

Other researchers suggest that misled participants truly believe that the post-event information occurred in the original event, but that the original item still remains intact in memory (e.g., Schooler, Gerhard & Loftus, 1986; Lindsay & Johnson, 1989a; Lindsay, 1990; Weingardt, Loftus & Lindsay, 1995). Misled participants have even stated that they saw the misleading item that they read about in the original slide sequence (Belli et al., 1994; Weingardt et al., 1995). The source monitoring approach suggests that, while the original trace and the misinformation coexist, the misinformation had no direct affect on the original trace. As the original event and the misinformation source are both highly similar the standard misinformation paradigm fosters the ideal conditions necessary for misled participants to fail to discriminate the two contexts. Thus, the misinformation is perceived as belonging to the original event by misled participants (Schooler et al., 1986; Lindsay, 1990).

Does Misinformation Really Impair Memory for an Event?

There is also some circumstantial evidence that misinformation impairs memory for an event. Misled participants are typically just as confident that the misinformation item originated from the slide sequence as they are about real original items (Cole & Loftus, 1979; Greene et al., 1982; E.F. Loftus et al., 1989). However, given that confidence is not a strong correlate of memory accuracy in eyewitness testimony research (e.g., Shaw & McClure, 1995; Sporer, Penrod, Read & Cutler, 1995), this finding of a high degree of confidence in the misinformation item would mean very little without the more direct measures of memory, such as reaction times (e.g., E.F. Loftus et al., 1989). Not only can misled participants be confident about the origins of misleading information, but misled participants are also able to provide quite detailed descriptions of the misinformation item (E.F. Loftus, 1979a; Schooler et al., 1986). While the descriptions provided by misled participants of the misinformation item are similar on some dimensions, such as geographic detail, they do differ in some respects to descriptions of real events. For example, Schooler et al. (1986) found that when using the typical misinformation paradigm with the stop and yield road signs, misled participants tended to provide fewer sensory details (e.g., colour, shape, size, etc.), and provide many more references to the function of the misleading road sign. In addition, misled participants tended to provide more details concerning their cognitive processes during the slide sequence and while reading the narrative (e.g., what participants were thinking of or paying attention to). Misled participants also provided many more 'verbal hedges' during their descriptions of the misinformation item. That is, these participants had a habit of saying verbal hedges, such as 'I think' or 'I believe', during their descriptions of the suggested details. However, despite these differences, misled participants were unaware of these differences in their

descriptions of real and suggested details from an event. While untrained judges who were asked to attend to these descriptions and distinguish the real from the suggested details were aware of these differences they were still unable to successfully differentiate these items. This latter point is quite remarkable given that the misinformation item was a written word contained in a written text, while their description of it appears to be based on a visual memory of it.

The Non-retention Account of Misinformation Effects

For many years, there has been much debate concerning the placement of the original item in direct competition with the misinformation, and whether including the original item at test is an appropriate method for examining misinformation effects. McCloskey and Zaragoza (1985a) suggested that, in order to address whether the trace of the original item has been erased by the misinformation, the original item should not be placed in competition with the misinformation. Their reasoning is that if the trace of the original item has been erased by the misinformation then when participants are faced with a choice between the original item and a new item on a recognition test, these misled participants will perform at chance levels. That is, without an intact memory of the original item, misled participants will be forced to guess.

In short, McCloskey and Zaragoza (1985a) proposed that misinformation had no effect on memory at all and that the misinformation effect is actually due to demand characteristics inherent in the misinformation paradigm. Misled participants who fail to recall the original item due to reasons other than the presentation of misinformation may remember the misinformation from the narrative, and therefore choose the misinformation at the recognition task. The misinformation will have no

effect on the original trace because there was no trace at the time of misinformation exposure. The misinformation merely acts as additional information filling a hole in memory (Pirolli & Mitterer, 1984), and thus this account of misinformation effects has become known as the *non-retention account*.

If it is assumed that the null hypothesis is correct, and that misinformation has no effect on memory, then certain assumptions can be made concerning performance at test. In the control condition, participants receive no post-event information, and so are not expected to demonstrate a misinformation effect. Control participants who remember seeing the original item during the slide sequence will select that item at test when given a choice between the original item and the misinformation (new) item. However, a proportion of participants will always fail to either encode the original information in the first place, or will forget it during the retention interval between the study and testing phase. The control participants who do not remember the original item can be expected to guess on a test between the original item and the misinformation item. McCloskey and Zaragoza (1985a) supply a hypothetical situation in order to illustrate their point where 40% of control participants who receive no post-event information remember seeing the original item during the slide sequence. However, this means that 60% of control participants did not recall the original item (for various reasons), and so they are likely to guess on a recognition test and perform at chance levels with 30% choosing the original item and 30% choosing the misinformation item. Thus, 70% of control participants will choose the original item on a recognition test (40% + 30%).

On the other hand, misled participants are likely to perform more poorly on this recognition test than are control participants even if misinformation has no effect. This assumption works on the basis that a certain proportion of the misled participants

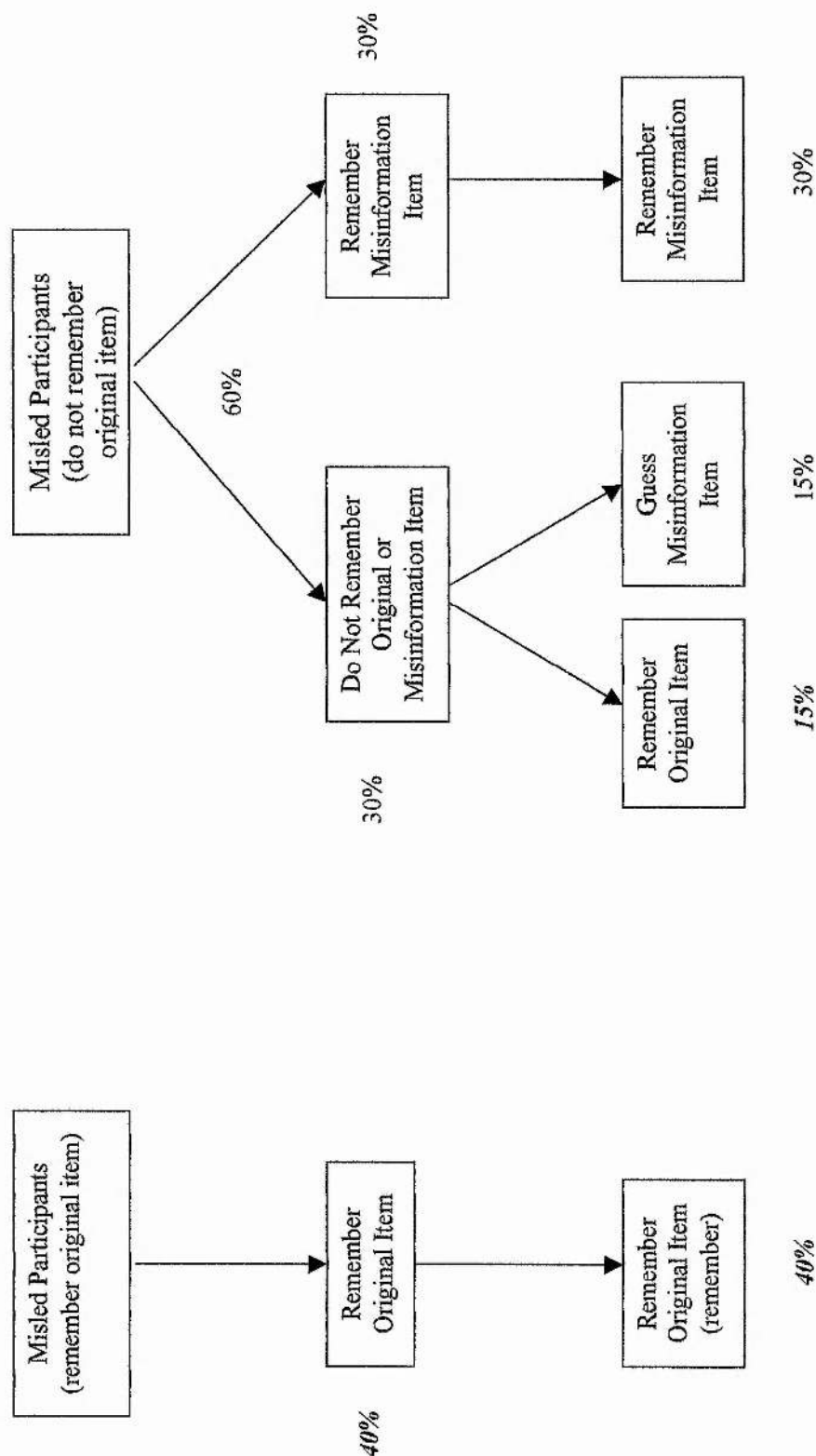
who did not recall the original item will recall the misinformation item from the post-event information. For example, if the same proportion of misled participants recall the original item (i.e., 40%), then the remaining 60% will have no memory of that original item. Half of these participants (i.e., 30%) will remember the misinformation item that appeared during the post-event information phase, and so will choose the misinformation at test. However, half of the participants (i.e., 30%) will also have no memory of the misinformation item either, perhaps because it was never encoded, or because it has been forgotten during the retention interval between the post-event information and the recognition test. With no memory of either the original item or the misinformation, when given a choice between those items on a recognition test, half of these participants will guess the original item (i.e., 15%), and half will guess the misinformation item (i.e., 15%). Thus, only 55% of misled participants will choose the original item (i.e., the 40% who recall the original item, and the 15% who guessed it), while 45% will choose the misinformation item (i.e., the 30% who recall the misinformation item, and the 15% who guessed it), compared to 70% of control participants choosing the original item, see Figure 18.

So, if it is assumed that the misinformation has no effect on memory for an event, misled participants will always perform more poorly than control participants, even if the same proportion of participants in both conditions can remember the original item. Thus, a misinformation effect will occur in the absence of memory alteration as long as a proportion of misled participants fail to remember the original item (for reasons not related to trace alteration or destruction); and a proportion of the misled participants who fail to recall the original item remember the misinformation item instead.

There is also a third possible source that may contribute towards the misinformation effect. In the misled condition, a proportion of participants who recall the original item will also recall the misinformation item as well, see Figure 19. If it is assumed that 40% of misled participants recall the original item, then half of these participants may also recall the misinformation item (i.e., 20%). These misled participants who remember both the original item and the misinformation item will have to come to a decision over which item they intend to choose at test. Half of these participants who vividly recall the original item occurring in the slides will favour the original item on a recognition test (i.e., 10%). On the other hand, half of the participants may consider that, as the experimenter prepared the post-event information they must surely know what was contained within the slides, and so these participants are likely to choose the misinformation item (i.e., 10%). Under these conditions, only 45% of misled participants will choose the original item at test (compared to 70% of controls), and 55% will choose the misinformation item.

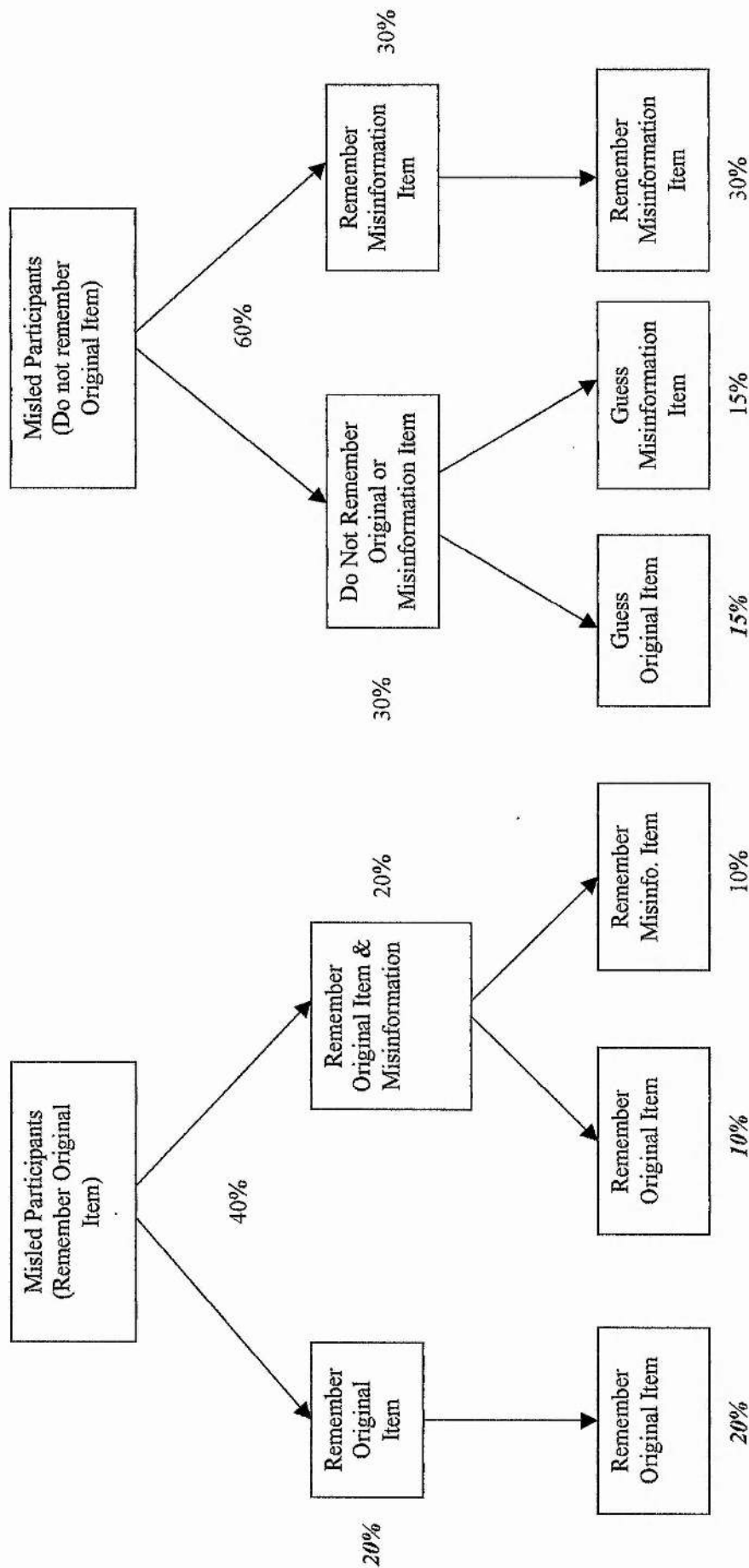
Thus, according to McCloskey and Zaragoza, the standard misinformation paradigm is inadequate for testing the hypothesis that misinformation affects memory for an event. The primary problem is the recognition test that is typically employed where the original item is placed in competition with the misinformation item. As there will always be a proportion of control and misled participants who fail to recall the original item, control participants will have a 50% chance of guessing correctly. Control participants will therefore always perform better than misled participants who do not recall the original item as they have less than a 50% chance in guessing the original item (as their choice is biased from remembering the misinformation and not the original item).

Figure 18: Guessing bias inherent to typical misinformation paradigm



Note. 55% of misled participants choose the correct original item (40 + 15), while 45% of misled participants choose the misinformation item (15 + 30), even though misinformation has no effect on memory.

Figure 19: Demand characteristics inherent to the typical misinformation paradigm



Note. The above diagram only concerns the choices of participants who receive misleading post-event information. Only 45% of misled participants choose the correct original (20 + 10 + 15), while 55% of misled participants choose the misinformation item (15 + 30), even though misinformation has no effect on memory.

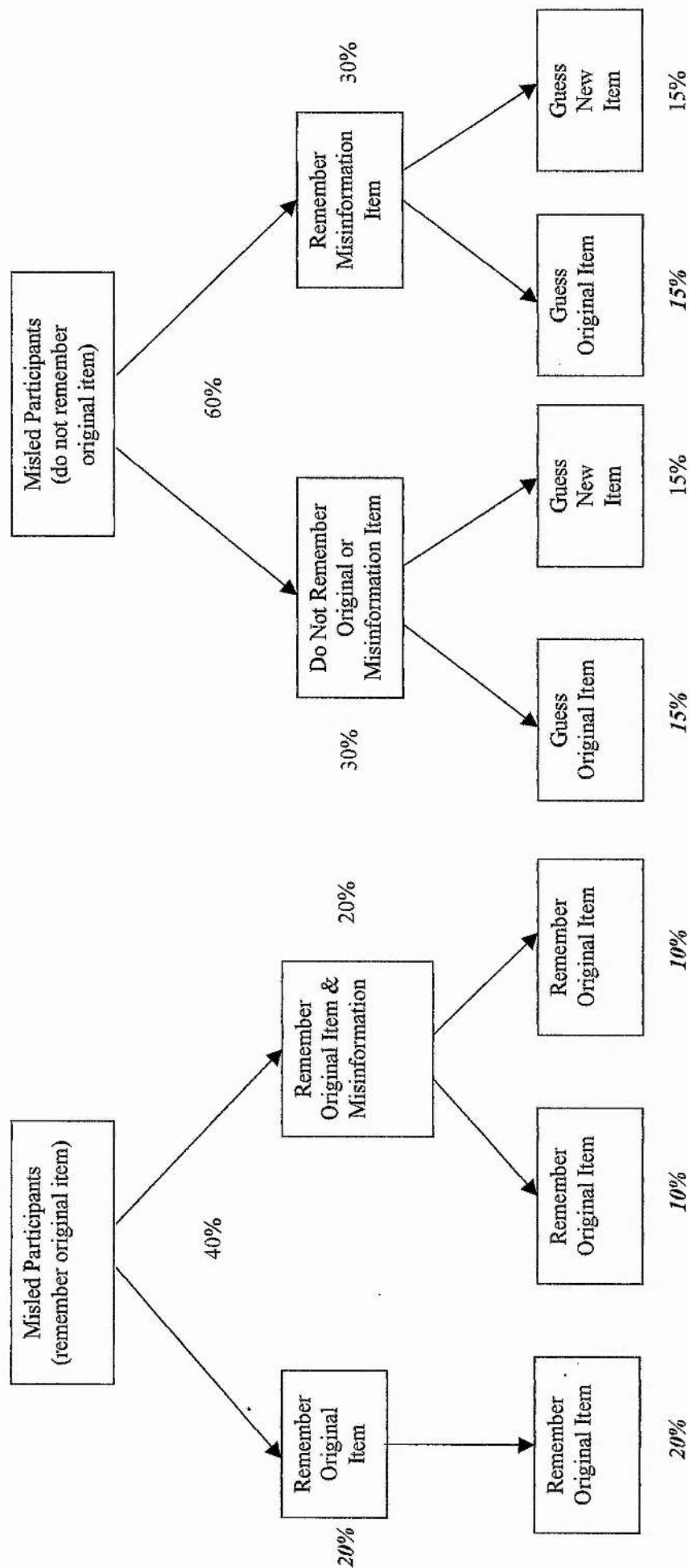
McCloskey and Zaragoza (1985a) suggest an alternative recognition test, called the modified test procedure, that they believe is more appropriate for studying the hypothesis that misinformation alters memory for an event. This modified recognition test does not place the original item in competition with the misinformation item, but rather forces participants to choose between the original and a novel item. Thus, participants in the misled condition who have no memory for the original item but do remember the misinformation, are not biased by the choices available on the recognition test. If the trace of the original item had been erased or destroyed by the introduction of misinformation, then misled participants should perform at chance levels on this modified test. That is, if misled participants have no memory of the original item they should be forced to guess on this test. In contrast if misinformation does not erase the original item, then misled participants will choose the original item.

Using this new recognition test should not affect control participants performance and so they should perform at the same level as on the standard test. In McCloskey and Zaragoza's (1985a) example, control participants will choose the original item 70% of the time (40% who explicitly remember the original item, and 30% who guessed correctly). In the misled condition, 40% of participants may recall the original item, with half of those participants also recalling the misinformation item as well (i.e., 20%). Under these conditions, as the misinformation item is not a choice on the test, all of these participants will choose the other item that they do remember: the original item. The remaining 60% of misled participants will have no memory for the original item (and as before, this will be for reasons unrelated to the misinformation having an effect on memory for the event). Half of these misled participants will remember the misinformation item (i.e., 30%). However, as the

misinformation item is not an available choice on the recognition test, half of these participants will guess the original item (i.e., 15%), and the other half will guess the new item (i.e., 15%). Out of the remaining misled participants who do not recall the original item, they will also have no memory of the misinformation item as well (i.e., 30%). Under these circumstances, half of the misled participants will guess the original item (i.e., 15%), and half will guess the new item (i.e., 15%). So, if the null hypothesis is assumed to be correct, and the misinformation did not erase the original memory, performance in the misled condition should be the same as in the control condition. That is, the guessing rates are equal in both the control and misled condition resulting in 70% of participants from each condition choosing the original item, see Figure 20.

McCloskey and Zaragoza (1985a) compared the effects of introducing misinformation on the standard recognition test (i.e., original versus misinformation item) with that of the modified test procedure (i.e., original versus new item). Across six experiments, misled participants typically performed poorer on the standard test than the modified test. That is, in the standard recognition procedure, misled participants recalled the original item less than control participants, demonstrating a significant misinformation effect. In contrast, misled participants recalled the original item at the same level as control participants when a modified recognition test was used. That is, when misled participants are given a choice between the original item and a new item, they tend to choose the original item, eliminating the misinformation effect. Therefore, the results of the modified test procedure appear to confirm McCloskey and Zaragoza's assumptions concerning demand characteristics, differential guessing rates between the misled and control conditions, and the misinformation bias in the standard recognition test.

Figure 20: Modified recognition test in the misinformation procedure



Note. The above diagram only concerns the choices of participants who receive misleading post-event information. 70% of misled participants choose the correct original item ($20 + 10 + 10 + 15 + 15$), while only 30% of misled participants choose the misinformation item ($15 + 15$).

When these factors are controlled for in a recognition test, misinformation fails to influence participant's performance. On the other hand, if these factors are not controlled for (i.e., the standard recognition test), a significant misinformation effect occurs. Therefore, the null hypothesis that misinformation has no effect on memory for an event is affirmed.

Arguments against the Non-retention Account

Other researchers, however, have also examined the role of demand characteristics in producing source monitoring errors through adapting Jacoby, Woloshyn and Kelley's (1989) 'logic of opposition' paradigm, such as Lindsay (1990). The application of this paradigm to a source monitoring test places the participant's desire to report the misleading item in opposition with their ability to recall the source of that item. Participants were told just prior to test that all information contained within the narrative was false and participants should not base their responses on information from this source. Thus, reporting the misinformation item would go against the demand characteristics set up by the experimenter's instructions not to base their responses on the post-event information. When there was a high degree of discrimination between the original event and the post-event information through inserting a two-day delay between these phases, misled participants were very successful in only reporting details from the original event. On the other hand, participants who viewed both the original event and the post-event information within the same session mistakenly recalled the misinformation item. These participants were unable to discriminate successfully information that occurred in the original event from information that came from the original event, and so would report the misinformation item in place of the original item. This suggests not only that demand

characteristics cannot always explain the misinformation effect, but also that participants are more likely to make a source monitoring error, and thus a misinformation effect, when the original event and post-event information are difficult to discriminate in memory.

Similarly, Zaragoza and Lane (1994) have found that misattribution of a suggested item to the original event is more likely to occur when participants answer suggestive questions rather than when they simply read a narrative containing suggestive details. According to the demand characteristic and guessing interpretation of source monitoring errors, the suggestive detail is just as likely to be misattributed to the original event in either condition. Thus, the differential effect of post-event information in the questioning and narrative conditions is unlikely to only be due to demand characteristics and guessing.

The logic of opposition task has also been adapted for an implicit memory task that can control for demand characteristics in the misinformation paradigm (Weingardt et al., 1995; Weingardt, Toland & Loftus, 1994). Once again, the desire of participants to recall the misinformation item successfully was placed in opposition with their ability to recall the source of that misinformation. Participants were given an implicit recall task that required them to generate exemplars of categories. Some items from the original event and the post-event information could fall into these categories, but participants were informed that they were not to add any items to these categories if they had seen those items in the slide sequence. For example, participants were asked to list the names of five magazines but not to report any magazines that they had seen in the slides. Under these retrieval instructions, misled participants were less likely to report the misinformation item than were control participants who did not receive misleading post-event information. This result

suggests that misled participants appear to believe that they actually saw the misinformation item in the original slide event.

Several researchers have also criticised the modified test as being unsuited to hypotheses that require the misinformation item to be a choice at test (Belli, 1989; Chandler, 1989; E.F. Loftus, Schooler & Wagenaar, 1985). While the modified test is suited to hypotheses concerning the destructive updating of the original item with the misinformation, it is not suitable for hypotheses concerning various retrieval failures or source monitoring errors that result from encountering misinformation. For example, a retrieval impairment explanation of the misinformation effect, called the blocking hypothesis, suggests that the high accessibility of the misinformation 'blocks' retrieval access to the original item (Belli et al., 1992; Chandler, 1991), normally through recency or saliency. Similarly, source misattribution does not require the presumption of impairment of the original trace, but suggests that both the original and misinformation item can be recalled (Lindsay, 1990; Lindsay & Johnson, 1989a; Zaragoza & Koshmider, 1989). Unfortunately, the removal of the misinformation item on the modified test prevents misled participants who mistakenly believe that the misinformation occurred during the original event from choosing the misinformation item. As even strict source monitoring instructions can fail to abolish the misinformation effect (Lindsay, 1990), it suggests that the selection of the misinformation item can be a very powerful and almost automatic choice. Thus, there may be an argument to be made for modified tests being insensitive to some retrieval interference accounts of memory impairment, which could conceivably produce a fairly natural account of misinformation effects.

Is the Modified Test Insensitive to Detecting Memory Impairment?

E.F. Loftus et al. (1985) have also criticised the modified test as being insensitive to the small proportion of misled participants who may have genuine memory impairments, or who have a blended memory of both the original item and the misinformation item. As the modified test is a two alternative forced-choice test, participants who guess will have a 50% chance of guessing correctly. Thus, any small genuine memory impairments are likely to be masked by this guessing. If a more sensitive measure is used that reduces the influence of guessing, even if it does not have the misinformation item as a choice on the test, fewer misled participants should choose the original item compared to participants who were not misled. E.F. Loftus et al. suggested that a 'betting form' method that allows participants to distribute weights to their choices would be sufficiently sensitive to detect real memory impairment. In fact, Benzing (1985, quoted in E.F. Loftus et al., 1985) used this betting form method in both the standard recognition test (i.e., original item vs. misinformation), and in the modified test (i.e., original item vs. new item). While fewer misled participants chose the original item in both types of test than did participants who had not received post-event misleading information, a smaller misinformation effect was found in the modified test. The difference between the two types of tests would be consistent with McCloskey and Zaragoza's (1985a) assertion that a proportion of misled participants may not have encoded the original item. However, as Benzing (1985) did find a misinformation effect, it would suggest that this proportion of participants who either fail to encode the original item or forget that item (for reasons other than the misinformation having any effect on the original item) is much smaller than the 60% that McCloskey and Zaragoza originally suggested.

Unfortunately, memory performance in the betting form test does not provide a pure measure of memory accuracy, but also participants' confidence in the accuracy of their memory. Exposure to misinformation may influence misled participants' confidence in their memory for both the original item and misinformation. Thus, misled participants have an intact memory for the original item, but the presentation of the misinformation item may decrease misled participants' confidence in the accuracy of their memory for the original item. On the other hand, control participants who are not exposed to misinformation will not have their confidence in their memory of the original item affected. Due to the difference in confidence between misled and control participants, misled participants may assign fewer points to the original items even if the misinformation item is not a choice at test.

Is E.F. Loftus et al. (1985) justified in criticising the modified recognition test as being insensitive to genuine memory impairment? Not entirely. Zaragoza and McCloskey (1989) addressed E.F. Loftus et al.'s criticism concerning the modified test, reiterating its applicability to all hypotheses that do not require the misinformation item to be an option on the test (e.g., does misinformation destroy the trace of the original item?), including hypotheses that concern the weakening of the original trace. While several researchers have failed to find a misinformation effect with the modified test (Belli, 1993; Bonto & Payne, 1991; E.F. Loftus et al., 1989; McCloskey & Zaragoza, 1985a; Zaragoza et al., 1987), others have been able to demonstrate misinformation effects with this modified test. Chandler and colleagues (Chandler, 1989, 1991; Chandler & Gargano, 1998) have consistently demonstrated strong misinformation effects using a modified test, although the paradigm was not of an eyewitness memory design. Chandler typically uses scenes from nature (e.g., leaves), with the post-event information, and the new item on the modified test,

looking quite similar to the original item. Misinformation effects can also be detected with the modified test if a sufficiently long retention interval (i.e., 3-7 days) occurs between the original event and the presentation of the post-event information (Belli et al., 1992; Ceci et al., 1987; Toglia et al., 1992). This suggests that a degree of forgetting for the original event (e.g., trace disintegration) must occur for the misinformation to be able to impair the memory for the original item (Belli et al., 1992), but not so much that the performance of the controls approaches chance levels (Chandler, 1989; E.F. Loftus et al., 1989). This interpretation of memory impairment occurring with the modified test is supported by prior findings that misinformation has a greater impairment effect on memory for an event when the trace of the original item has degraded over a longer retention interval with the standard test (E.F. Loftus et al., 1978). In contrast, misinformation effects tend not to be detected if the retention period is very short (i.e., 30 minutes or less; Belli et al., 1992; Bonto & Payne, 1991; Loftus et al., 1989; McCloskey & Zaragoza, 1985a). Misinformation effects have also been found using the modified test with pre-school children in a more typical misinformation paradigm (Ceci et al., 1987; Toglia et al., 1992).

Perhaps the most convincing evidence that the modified test lacks sensitivity comes from work measuring reaction times at test. While E.F. Loftus et al. (1989) found no evidence of a misinformation effect through measuring memory performance, a difference was found between misled participants' reaction times on the critical question and on non-critical questions. When misled participants are asked to choose between the original item and a never seen before item, participants typically take longer to choose between these items, irrespective of whether they finally choose the original item or not. On the other hand, misled participants are as fast to choose the original item on non-critical questions that they have not been

misled over as control participants are. This increased deliberation time on questions that participants have been misled over suggests that the misinformation has had at least some effect on memory for an event without affecting overall performance.

If, contrary to McCloskey and Zaragoza's (1985a) claims, there is at least some genuine memory impairment occurring in the misinformation effect, just how much memory impairment is actually occurring? Belli (1989) examined this question through adapting the modified test to a Yes/No task in order to try and produce a more sensitive test to misinformation effects while trying to reduce the influence of guessing. This Yes/No test was not a forced-choice test that requires participants to choose between two items. Instead, half of the slides presented during the recognition test were original items, and the remaining half were new items, and participants had to evaluate each item individually and decide whether it had occurred in the original event or not. Using this test, 'misinformation interference' (either through alteration or retrieval failures) was calculated as contributing to the production of misinformation effects. Belli suggested that 32.6% of control participants had a memory for the original item, compared to only 26% of misled participants having an intact memory for the original item. While a 6.6% drop in memory performance for the original item seems quite small, Belli calculates that this drop in memory accuracy for the original item between the misled and control conditions means that misled participants actually suffered a 20.2% reduction in performance (6.6% of 32.6%) due to the introduction of misinformation in the post-event information. Thus, the introduction of misinformation can have a significant impairing effect on misled participants' memory for an event.

However, Belli (1989) obtained this memory impairment under very specific conditions. Post-event information was presented only five minutes after the original

event, and the test occurred after a further ten minutes. When these timings were doubled, no evidence was found for memory impairment. In fact, there was instead strong evidence for the biasing effect of misinformation on guessing rates, and of demand characteristics (Belli groups these non-cognitive explanations together as indicating 'misinformation acceptance'), as well as poor retention of the original item in the control condition. However, Belli's paradigm does not differentiate the effects of memory impairment (e.g., trace alteration, retrieval failure) from source monitoring errors, which requires no assumptions concerning memory impairment. Thus, the misinformation effect in Belli's study could be entirely due to source misattribution of the misinformation to the original event, memory impairment, or a combination of both effects. Despite this, the results do imply that misinformation can affect memory for an event, at least under specific conditions, and that non-retention of the original item and misinformation acceptance probably plays a significant role in the large misinformation effects typically found in many studies.

Trace Alteration Reconsidered: I. Weakening of the Original Trace

E.F. Loftus and colleagues' original interpretation of the misinformation effect suggested that the original trace was completely erased (e.g., E.F. Loftus, 1979a, 1979b; E.F. Loftus & Loftus, 1980; E.F. Loftus et al., 1978). This erasure of the original trace was believed to occur through the activation of a destructive updating mechanism when participants encountered additional or contradictory information. As only one representation could exist in memory for an event, exposure to information that contradicted what was already stored in memory required the trace corresponding to the original item to be destroyed and replaced by the new

misinformation item. Thus, the single representation in memory for the event was updated with this new information.

However, after McCloskey and Zaragoza's (1985a, 1985b) attack on the typical E.F. Loftus misinformation paradigm, and their assertion that misinformation has no effect on memory for an event, E.F. Loftus and colleagues reconsidered their position. What other reasons could explain why the misinformation effect was abolished when the misinformation item was removed as an option on the modified recognition test? As already noted, various researchers considered the possibility that perhaps a smaller proportion of misled participant's memory of the original item was erased by the misinformation than originally thought (e.g., Belli, 1989; E.F. Loftus et al., 1985), and that the modified test was insufficiently sensitive to detect this small impairment. Further to this, the alteration hypothesis was modified to include the possibility that the original trace is 'weakened' or 'fades' through subsequent exposure to misinformation (E.F. Loftus & Hoffman, 1989), or there is a 'disintegration' of features that constitute an original trace (Brainerd & Reyna, 1988, described in E.F. Loftus & Hoffman, 1989). So, under what conditions would the weakening, fading or disintegration of the original trace be promoted? As a weakened or faded trace should be much easier to alter than a stronger trace, the most obvious and simplest manipulation would be to vary the retention interval between the original event and the introduction of misinformation and application of the final recognition test.

There is some evidence to support this view of the alteration hypothesis. Misinformation has been shown to have less of an influence on memory for an event when the post-event information is presented and tested immediately, or soon after, viewing the original event with the standard test (e.g., from 20 minutes to one day,

E.F. Loftus et al., 1978). It should be noted, however, that even at these fairly brief retention intervals misled participants still only choose the original item around 40% of the time. However, with short retention intervals on the modified test, misinformation effects are typically not detected (Belli et al., 1992; Bonto & Payne, 1991; Loftus et al., 1989; McCloskey & Zaragoza, 1985a). At these short intervals, the original item and the event are believed to be fresh in memory, resulting in a stronger original trace.

Stronger misinformation effects are typically found with longer retention intervals, usually between one day and one week between the original event and the introduction of misinformation with the standard test (E.F. Loftus et al., 1978). This pattern of increased misinformation influence is found even when the modified recognition test is used (Belli et al., 1992; Ceci et al., 1987; Toglia et al., 1992). Retention intervals of around a day appear to be the beginning of this transition from a sufficiently strong trace to a weaker trace. Under these longer retention intervals, the original trace is expected to have weakened through time and disuse making it easier to alter the original memory.

What happens if the misinformation trace is also weakened through time and disuse? E.F. Loftus et al. (1978) found a general trend toward misled participants performing at chance levels over the period of one day to one week. After a week had elapsed between the presentation of the post-event information and the final test, both misled, and control participants who had received no post-event information, appeared to be guessing between the original and misinformation item on a standard test (E.F. Loftus et al., 1978). However, this pattern does not always occur and the misinformation item can continue to influence misled participants' performance at test even when it is presented from three to nine days before a modified test (Ceci et al.,

1987; Howe, 1991). However, these latter studies used young children as participants with stories as stimuli. It has been suggested that young children are more susceptible to misinformation because they lack the awareness needed to monitor the credibility of the post-event information (Ceci et al., 1987). On the other hand, misinformation effects are typically found with the standard test when the post-event information is presented shortly before testing (e.g., E.F. Loftus et al., 1989; McSpadden, Schooler & Loftus, 1998; Zaragoza & Koshmider, 1989). These results suggest that the misinformation effect can be dependent on the strength of the misinformation trace. However, this issue does not seem to be as cut and dry as with the strength of the original trace. When the trace is strong in adult participants, they are more likely to choose the misleading item. If the misinformation trace is relatively weak, however, in addition to the original trace being even weaker, both of these items are in a relatively poor retrieval position.

Thus, there appears to be some evidence in favour of weak original traces being susceptible to misinformation effects. The original trace may be altered by the misinformation either through a weakening, fading, disintegration of features of the trace, or perhaps some unknown alteration but the exact mechanism remains unknown. On the other hand, if both the original trace and the misinformation trace are relatively weak, then participants merely perform at chance levels.

The original trace can also be strengthened through re-presenting the original slide sequence. When the original item is strengthened through this method, misinformation tends not to have any effect on participant's memory for the event. (Shaughnessy & Mand, 1982). Presumably, the re-presentation of the original item strengthened the original trace compared to the misinformation item that was only presented once. However, this reasoning suggests that if the misinformation item is

strengthened through its re-presentation, then a misinformation effect will always occur. Unfortunately, this is not always so. McCloskey and Zaragoza (1985a) presented the post-event information either once or twice, and found no difference in the magnitude of the misinformation effect, regardless of whether the standard and modified test was used.

Trace Alteration Reconsidered: II. Blended Memories

E.F. Loftus et al. (1985) also suggested that the modified recognition test was insufficiently sensitive to detect blended memories. Blend memories are new memories that contain features of both the original item and the misinformation item, but are not an exact match to either item. Thus, blended memories can be seen as evidence that the misinformation does impair or 'corrupt' the original memory, but not to the same degree as the original destructive updating mechanism suggested. However, it should be noted that this explanation of exactly what constitutes a blended memory never arose from E.F. Loftus' early work on blend memories (E.F. Loftus, 1975, 1977), and she has never actually completed any further empirical work on blended memories since those early studies. This account of blended memories was a more fleshed out variation of the original concept that occurred primarily as a reaction to McCloskey and Zaragoza's (1985a) criticisms. In fact, McCloskey and Zaragoza (1985b) noted that 'the notion is not sufficiently well developed to merit serious consideration' (p.386).

Studies of blend memories are not a particularly easy phenomenon to study. There are few instances of objects (i.e., original item and misinformation) that could theoretically be blended to form a real object. For example, there is no real blend of a Stop and a Yield sign, or of Coke and 7-Up cans, or of apples and oranges. However,

E.F. Loftus et al. (1985) do comment that there is a 'screwrench', although it is not a tool that is both a screwdriver and a wrench. Despite this, there are some examples of things that can theoretically produce blends, typically things that can form a continuum or scale, such as colour, numbers of objects, and the size, volume or length of objects, speed, or perhaps even music. E.F. Loftus has examined the effects of blending in colour memory and memory for numbers of demonstrators. In one such study, E.F. Loftus (1977) examined the effects of exposing participants to misleading information concerning the colour of a car. Participants viewed a green car, which failed to stop at the scene of an accident, and then either received misleading information that the car was actually blue, or received no post-event information concerning its colour. Using a colour scale, participants who viewed a green car and where later told that it had been blue, were more likely to say that it had been of a blue-green hue on a recognition task than were control participants who had not been subjected to misleading post-event information. In addition, some misled participants chose a more bluer-green than other misled participants, suggesting that the post-event information had varying effects on individual participant's memory for the original item. E.F. Loftus (1975) found a similar result of blending with memory for numbers of demonstrators. Participants viewed a video of eight demonstrators, and later received post-event information that there had actually been four or twelve demonstrators in the video. Participant who were told that there was only four demonstrators thought that approximately 6.4 demonstrators had been present, while participants who received post-event information that there had been twelve demonstrators, estimated that approximately 8.9 demonstrators had been present in the video.

The original explanations for these blended memories were rather vague, merely mentioning the integration of both the original item and the misleading item into memory for the event, resulting on a single memorial representation of the event. However, in light of McCloskey and Zaragoza's (1985a) criticism of the destructive updating hypothesis, the idea of blended memories was again advanced as a possibility, and was considerably expanded upon.

As already noted, several researchers have suggested that the standard recognition test (i.e., original item vs. misinformation) is appropriate for testing hypotheses that require the misinformation item to be an option at test (Belli, 1989; Chandler, 1989; E.F. Loftus et al., 1992; E.F. Loftus et al., 1985). In the case of blended memories it could be argued that, to determine whether misled participants have an intact original memory, rather than a blended memory, it is necessary to have a recognition test that requires those participants to choose between the original item and a blended memory. This argument receives some support from a study by Weinberg, Wadsworth and Baron (1983) who employed a modified test consisting of an original item (i.e., yellow yield sign) and a blended item (i.e., red yield sign). This blended item contained features of the original item (the shape) and of the misinformation item (the colour). Despite a red yield sign being a fictitious road sign, participants performed poorer in the misled condition, even with this modified test. Therefore, these results can be interpreted in favour of the blending hypothesis: when given the choice between the original item and a blend, misled participants favour the blended item because it is a more appropriate match to their memorial representation.

Similarly, if misled participants have a blended memory consisting of some features from the original item, but the majority from the misinformation item, then removing the misinformation item as a choice from the test prevents participants from

choosing that item. This is despite the misinformation item being a better match to the memorial representation that is presumably stored in memory. Given the choice between the original item and a new item, there may be just enough features from the original item remaining within the blended memory for misled participants to choose that item. For example, consider participants who receive post-event information concerning the colour of a car. The true colour of the car is green, but misled participants receive misleading information suggesting that the car is actually blue. If it is assumed that blending does occur, then a blending of the original colour (i.e., green) with the suggested colour (i.e., blue) may be relatively unsuccessful with only slight changes occurring to the original trace (e.g., a subtle blue-green mix). Given a modified test where participants have to choose between the original and a new item, there may be sufficient features remaining of the original green car for misled participants to choose the original item. However, this choice of the original item may not be a particularly good match to misled participant's memory. In contrast, many features of the misleading information may blend with the original trace, resulting in a blended trace that contains few features of the original item (e.g., a very blue-green mix). Thus, E.F. Loftus et al. (1985) suggested that this modified recognition test was insensitive to real alterations in the original trace, either through erasure (which could occur for a small proportion of misled participants), or through blending with the misinformation item. Therefore, the standard recognition test is an appropriate and sufficiently sensitive test for examining blended memorial representations.

The only published empirical study examining blends since the re-advancement of the blending hypothesis has been by Belli (1988), who examined how much influence the misinformation colour and the original colour memory actually

have on blends. Belli suggested that participants' preconceptions about the typical colour of an item may actually have more influence on blends than the colour suggested in the post-event information. A large body of research on the role of schemata in recall suggests that an individual's knowledge and understanding of the world influences how we remember an event (Bartlett, 1932; Brewer & Treyens, 1981; Friedman, 1979). That is, we are influenced by what we see as 'typical' of a situation, or an object, or a person, etc. However, preconceptions tend to have a greater influence on memory when a memory test is delayed, and that this influence increases with increasing delays (Crosland, 1921; Daniel, 1972; Graesser, Woll, Kowalski & Smith, 1980). First of all, Belli measured participant's preconceptions concerning the colour of a water pitcher, which participants deemed was typically yellow. This being so, the colour of the pitcher in the original slide sequence was green. Belli found that even when no post-event information was presented on this green pitcher, participants tended to favour a yellowish-green or greenish-yellow hue when identifying the original colour of the pitcher. This influence of a typical yellow colour also became slightly stronger with increasing delay, although the typical yellow colour seemed to have a very strong influence on memory even with no delay. Thus, there seems to be evidence that the typicality of the colour of pitchers can shift memory for that pitcher away from the original colour (e.g., green) towards a hue that is a mixture of both the original colour and the typical colour of yellow.

Belli (1988) found an influence of this typical colour even after the introduction of misleading post-event information that tended to lead to participants' choices being clustered round the original colour, the misinformation, or the typical colour. After viewing the slide sequence that contained the green water pitcher, participants either received misleading information that the pitcher was blue, no post-

event information concerning the colour of the pitcher, or post-event information that was consistent with the *typical* colour of a pitcher (i.e., yellow). This manipulation of the post-event information produced some very interesting results. Participants who received post-event misleading information suggesting that the pitcher was blue tended to either choose the colour blue (the misinformation) or green (the original colour). On the other hand, participants who received post-event misleading information that was consistent with the typical colour of a pitcher (i.e., yellow), tended to choose colours that were primarily spread round that colour (i.e., hues that were greenish yellow and yellow), with a second smaller cluster around the original colour green.

There was some evidence of the post-event information skewing participants' responses towards the end of the spectrum suggested by the post-event information. This seemed to be due to the blue misinformation skewing responses towards the blue-green spectrum, while the yellow misinformation skewed responses towards the yellowish green spectrum. This meant that participants who received blue misinformation rarely chose hues from the orange – red spectrum, as the blue misinformation biased choices towards the blue end of the spectrum. On the other hand, participants who received yellow misinformation rarely chose hues from the blue – purple spectrum, as the yellow misinformation seemed to bias participants towards the yellow – orange end of the spectrum. This is perhaps due to the post-event yellow information 'confirming' participants' preferences towards this colour, while the blue misinformation pushes participant's memory towards a colour less consistent with that typical colour. However, as the original colour green appears closer to the blue end of the spectrum, this meant that participants who received post-event information that the pitcher was blue chose the original colour green twice as

much as participants who received post-event information in keeping with the typical colour. The influence of typical colour could also be seen in a control condition where no post-event information about the colour of the pitcher was presented. While very few participants actually chose a pure yellow hue, choices were spread around a green – yellowish green – greenish yellow spectrum, with a second cluster around the yellowish orange – red spectrum. Very few responses were made in the blue – purple spectrum.

Was there any evidence for blending? There was little evidence for a blending of misinformation that was inconsistent with the typical colour of a pitcher (i.e., blue) with the original green colour. In this blue misinformation condition, out of three bluish green hues, fewer than 10% of participants chose a bluish green compromise. As already stated, participants in this condition were far more likely to either choose the original colour or the misinformation colour. However, when the post-event misleading information was consistent with the typical colour of a pitcher (i.e., yellow), there was more evidence of blending of this typical colour with the original colour. Nearly 40% of participants in this yellow misinformation condition chose a yellowish green – greenish yellow compromise, while nearly half of participants who received no post-event information concerning the colour of the pitcher chose a yellowish green – greenish yellow compromise. Thus, post-event misinformation tended to result in far more colour blends when it was consistent with the typical colour of the pitcher, than when it was inconsistent with the typical colour. However, in the absence of post-event information, typical colouration, or ‘pre-event’ information, can also strongly influence participant’s choices.

Trace Alteration Reconsidered: III. Are Blended Memories due to Deliberate Compromises?

But are these blends the result of deliberate compromises (McCloskey & Zaragoza, 1985a, 1985b, although more fully developed by Belli, 1988), or genuine blending of information in memory? If misled participants have an intact memory of the original item and the misinformation item, and were making a deliberate compromise between the two colours, then participants who received blue misinformation and those who received yellow misinformation should have approximately the same number of blends. However, this was clearly not the case, with very few participants who received blue misinformation choosing a blue green blend, compared to the high number of yellow green blends demonstrated by participants who had received yellow misinformation. In addition, participants who received no post-event information were still influenced by typical colouration, a source of influence on their memories that participants were probably unaware of. Thus, it is unlikely that deliberate compromises between the original item and the misinformation would account for a majority of the choices at test in the misinformation conditions (and none in the 'no post-event information condition'). Further to this, participants who have no memory for the original item may base their responses solely on the post-event colour, the typical colour, or a deliberate compromise between the two. However, the few compromises in the blue misinformation condition would suggest that only a minority of participants may have based their choices on the post-event information, the typical colour, or some deliberate compromise between the two.

Therefore, there does seem to be some evidence for genuine blending of information in memory. However, how much of this blending is actually due to post-event information that is contrary to typical colouration blending with the original

item, and how much is due to deliberate compromises remains unknown. There seems to be more evidence for blending between the original colour and the post-event information if it is consistent with typical colouration, although again, how much of this is genuine memory impairment and how much is a deliberate compromise also remains unknown. Belli's (1988) work would seem to indicate that participants are most likely to choose either the original colour, or the misinformation colour, at test, rather than a high proportion of participants choosing a blend of the two colours. On the other hand, if the post-event misinformation is consistent with participants' preconceptions concerning the typical colour of an object, participants are more likely to choose a blend of that typical colour and the original colour. This suggests that participants are not just influenced by the original item and the misinformation item at test, as previously assumed, but are also influenced by their own pre-experimental knowledge.

Unfortunately, Belli's (1988) results add little to our understanding of how blended memories would occur. McCloskey and Zaragoza (1985b) complained that E.F. Loftus et al.'s (1985) descriptions of how blends would occur seemed to assume that 'intelligent' blends would occur, whereby there could only be one possible outcome (e.g., a red yield sign rather than a yellow stop sign). Belli's findings that post-event information and typical colour information bias participants to favour one end of the spectrum over another demonstrates that blended memories would appear to be hard to predict and quite messy. For example, a green pitcher plus yellow misinformation does not equal a green yellow pitcher, but results in participants choosing colours ranging from green through yellow through to yellowish orange. Thus, each individual participant could have an intact memory of the green pitcher, an intact memory of a yellow pitcher, or some ill-defined blend in-between.

However, McCloskey and Zaragoza (1985b) are as equally critical of the idea of blended memories as they are over the notion of misinformation erasing the original memory. As the alteration hypothesis continues to be discussed even after the development of the blending hypothesis, under what condition will trace alteration occur, and what conditions will trace blending occur? McCloskey and Zaragoza also remain unsatisfied over how blending actually occurs and wonder why a red sign plus a yellow yield sign results in a red yield sign and not some other configuration (e.g., a yellow stop sign, an orange sign with 5.5 sides)? McCloskey and Zaragoza referred to E.F. Loftus et al.'s (1985) assumptions concerning blended memories as always resulting in 'intelligent' and 'selective' blending when, theoretically, it should be possible to produce some very strange and unusual blends, that are neither 'intelligent' nor intuitive.

Trace Alteration Reconsidered: IV. Performance Blends or Representational Blends?

Metcalf (1990) attempted to address some of the issues concerning those processes in memory that could produce intelligent blends in eyewitness memory by examining blended memories within the composite trace model CHARM (Composite Holographic Associative Recall Model). CHARM is a distributed and associative model that proposes that individual memorial traces are stored together as superimposed, or blended, traces in the same layer of a network. This assumes that information that is encoded at the same time and from the same event has many shared features, and that these traces are likely to be associated with each other, compressed and stored in a single composite. As an analogy, composite memories can be thought of as overlapping transparencies. During the retrieval of this new blended memory, the composite trace is compared and matched with the whole

lexicon. The most appropriate match is then recalled. Concerning E.F. Loftus et al.'s (1985) notion of intelligent blends, Metcalfe proposed that prior knowledge and experience guide the blending of traces. Thus, stored knowledge will only allow 'coherent' blends to occur, and prevent the production of 'incoherent' blends.

Metcalfe (1990) has applied CHARM to the misinformation effect in an attempt to provide a formal set of processes and assumptions concerning how and when misinformation will impair memory for an event. Thus, CHARM not only attempts to explain blended memories found using stimuli that lie on a continuum of answers (Belli, 1988; E.F. Loftus, 1975, 1977), but also the typical misinformation effects found (or not found) with two alternative forced-choice recognition tests (e.g., Belli, 1989; E.F. Loftus et al., 1978; McCloskey & Zaragoza, 1985a). CHARM proposes that the original and misinformation items are superimposed or blended to form a composite trace. Therefore, CHARM proposes that the original memory of an event is altered, or *transformed*, by post-event information. This occurs through a three-stage process that simulates the standard three-stage misinformation paradigm. During the study phase, two 'vectors' (a cue and an item) are associated to one another. For example, the vector 'man' (which also acts as a cue) is associated with the original item 'hammer'. During the post-event information phase, a second vector 'wrench' is also associated with the vector 'man', or, in the control condition, 'tool' is associated with 'man'. Thus, a composite memory is formed that associates both the original item and the misinformation with the shared vector 'man' in the memories of misled participants, resulting in a hammer/wrench blend. In contrast, in the control condition, participants have a composite memory that associates the original item with the neutral post-event information, resulting in a hammer/tool blend. These blends are then compared with the choices provided on a test. When participants are given a

variety of choices at test, that include the blended item as a possible response, then participants are more likely to choose that blend. This is due to the blended memory being either a perfect or very close match to the options provided at test.

However, given a restricted choice on a forced-choice recognition test where none of the options match this blend memory, choices are likely to be governed by the type of test employed. When two alternative forced-choice tests are used, the composite trace is compared with the two choices. The item on the test that best matches this composite trace is the most likely to be favoured by participants. Misled participants, given a choice between the original item and the misinformation, are less likely to choose the original item 'hammer' than are misled participants who have been given a choice between the original and a novel item. In simulations of a misinformation paradigm using CHARM, Metcalfe (1990) found that the original item was chosen less often in the standard recognition test than in the modified test. This is due to the two options in the standard test having been blended with the cue 'man', compared to only one of the options in the modified test.

Schooler and Tanaka (1991) have criticised the application of CHARM to misinformation effects as being vague in its use of the term 'memory blends'. It is unclear whether the term 'blended memory' within CHARM refers solely to performance on a test, or whether it also refers to an alteration to the underlying memorial representations. That is, Schooler and Tanaka suggest that there may in fact be two different classes of memory blends that are brought about by very different processes: performance blends and representational blends. In brief, performance blends do not require any assumptions to be made concerning the alteration of the underlying memorial representation, while representational blends assume that the underlying traces have been fundamentally altered.

Performance blends are memories that contain information that are based in either the original event or the post-event information. These types of memories take intact features from both of these sources and combine them, *through the retrieval process*, to form a single memory of the event. For example, in the misinformation paradigm, the car and the junction from the original event is combined with the yield sign from the post-event information to form a single blend memory of a car at a junction with a yield sign. Thus, these performance blends describe the basic empirical findings of poorer recognition of the original item in the misled condition, without ascribing any underlying changes to the memorial representation of the event in the production of misinformation effects. That is, performance blends are not the result of any erasure or alteration to the original memory, but instead are a product of the retrieval process, and may be a form of source monitoring errors (e.g., Lindsay, 1990; Lindsay & Johnson, 1989a; Zaragoza & Koshmider, 1989). This being so, the blending of the misinformation item with the original event may explain how misled participants come to believe that the misleading information actually occurred during the original event (Weingardt et al., 1995). Performance blends also make intuitive sense as we often mistakenly combine features from different autobiographical memories (e.g., Neisser, 1981). While the details contained within the blended memory may be accurate, they are drawn from incorrect sources.

Thus, there would appear to be quite strong empirical evidence for performance blends occurring in the misinformation paradigm, and in autobiographical memory. Unfortunately, there is little evidence from performance blends to support the mechanistic processes proposed by CHARM. This is because the features that constitute performance blends are intact features from either the original event or the post-event information and can be traced to these sources.

Therefore, performance blends can be explained without asserting any actual memory alterations. As CHARM assumes that the exposure to misleading post-event information alters memory by adding additional information to the memorial representation in order to assess the proposed mechanisms of CHARM, performance on a memory test must demonstrate that genuine memory alteration has occurred. This places performance blends in the same difficult situation as E.F. Loftus' destructive updating mechanism: it is impossible to demonstrate that the memory has been truly altered. Thus, McCloskey and Zaragoza's (1985a) non-retention explanation of misinformation effects, and supporters of the coexistence hypothesis (e.g., Bekerian & Bowers, 1983) provide alternative explanations of performance blends that would suggest that the original item and the misinformation are stored separately, and not a single composite memory. In addition, as the features from performance blends are features from both the original event and the post-event information, performance blends may demonstrate a memory reconstructed from multiple retrieval routes and sources.

Representational blends, on the other hand, can provide more support for the blending mechanisms of CHARM (E.F. Loftus et al., 1985; Metcalfe, 1990; Schooler & Tanaka, 1991). These types of blends produce a memory that may resemble both of its sources, but is not an exact match to either one of them. That is, information is taken from the original event and the post-event information and blended to produce a new memorial representation that had at least one feature that is not found in either source. As this blended memory contains new features that are not derived from the previously encountered sources, representational blends provide the strongest evidence for genuine blending of memory traces, and for the processes assumed by CHARM. However, while the notion of representational blends is more consistent

with the mechanisms that Metcalfe (1990) assumes produces composite memories within CHARM, there is mixed empirical support for these blends. As already noted, only three studies have investigated blend memories in the misinformation paradigm (Belli, 1988; E.F. Loftus, 1975, 1977). E.F. Loftus (1977) found evidence for the post-event information influencing misled participants to choose a blend of the misinformation and the original item, but Belli (1988) found little direct evidence for these blends. Instead, Belli found that misled participants preferred to choose either the original item (i.e., green) or the misinformation item (e.g., blue), rather than choose a specific blend of the two sources (only 8% of participants chose a bluish green blend). The only exception appeared to be when the post-event information was in line with participants' expectations concerning the colour of a water pitcher. When the misinformation matched participants' pre-conceptions (i.e., yellow), misled participants' choices at test were biased towards that end of the colour spectrum, resulting in far more yellow – green blends being chosen. Thus, while Belli's study demonstrates that misinformation can influence participant, it provides little evidence for genuine representational blends. In addition, CHARM does not exclusively predict that participants will choose a blend on a memory test. Schooler and Tanaka (1991) indicate that an 'interval storage hypothesis' suggested by categorisation models can also explain the production of representational blends (Neumann, 1977). Interval storage assumes that values on continuous scales are stored in intervals rather than exact points on that scale. This means that, in the case of memory blends, such as colour, rather than storing the exact colour hue in memory, participants may store a more general knowledge of the colour. For example, using Belli's colour scheme, if participants view a car whose colour is green hue 12, participants may store the general colour 'greenish', which consists of a set of colour values, rather than 'hue

12'. After participants are exposed to post-event information that the car was blue, misled participants may choose the bluest hue from the set of 'greenish' values that are stored in memory concerning the colour of the car. Thus, the post-event information could merely bias choices on a test, rather than seeing the blending of traces onto a single composite memory, as suggested by CHARM.

To summarise the empirical evidence, there is a great deal of support for performance blends, but little evidence to demonstrate that genuine memory alterations actually occur (i.e., blending between the original and misinformation item to form a single memory). Thus, performance blends provide little evidence to support the blending mechanisms proposed by CHARM and may actually reflect a memory comprised of intact features drawn from several retrieval sources. On the other hand, representational blends are generally accepted as providing the most compelling evidence in support of both CHARM and the blending of traces. However, there is weak empirical support for the blending of memorial representations to produce a new composite memory. In addition, an alternative storage interval model can account for the current evidence of blending, without having to assume that memorial representations are blended into a single and new memory.

A Possible Role for Retrieval Inhibition in the Misinformation Effect

It is apparent from this review that there is a great deal of variability within the literature as to the possible mechanisms underlying the misinformation effect. This lack of cohesiveness has resulted in the under-development of theories concerning possible updating mechanisms in memory. Not only does the presence, or magnitude, of the misinformation effect depend on the various manipulations employed (e.g.,

sequential testing, length of retention interval), but also the type of recognition test used. Even when only one test is considered, such as the modified test, findings vary dramatically between studies. While the modified test has repeatedly failed to demonstrate a misinformation effect (e.g., Belli, 1993; Bonto & Payne, 1991; McCloskey & Zaragoza, 1985a), others have demonstrated impaired performance (e.g., Belli et al., 1992; Ceci et al., 1987; Chandler, 1991). Interestingly, E.F. Loftus et al. (1989) failed to find any significant misinformation effect using the modified test, but did find that misled participants issued with this test typically took longer to choose an item for the critical question than they did to choose a non-critical item that they had not been misled over. This study, more than any other, highlights a problem with the misinformation literature: misled participants' performance at test may not always truly represent the state of underlying memorial representations. Thus, the misinformation effect most likely represents *performance change*, not *representational change*. This is similar to the problem identified with studies examining the cognitive interview. Recent research has suggested that the possibility that the retrieval techniques employed in the cognitive interview may have no effect on the accessibility of memorial representations, but instead affects the reporting criterion (Memon & Higham, 1999; Roberts & Higham, 2002). This argument has also been levelled at the effects of hypnosis on memory, suggesting that while it may increase the volume of information given in an interview, it has no effect on the availability of the memorial representations (Klatzky & Erdelyi, 1985).

There is a second related possibility concerning whether the misinformation effect is truly a measure of memory change (either permanent or transitory). It remains possible that there is representational change, but it is not registered in the performance of misled participants. For example, E.F. Loftus et al. (1989) found that

misled participants chose the original item in the modified test at the same level as non-misled control participants. However, misled participants were slower to choose the original item at test when their reaction times were measured and compared to the non-misled participants. This situation may occur for a variety of reasons, such as only a minority of the features of the original trace are affected (e.g., a weakening or disintegration of features, Brainerd & Reyna, 1988). Thus, here is an example of a small representational change without a change in performance on a recognition test.

Finally, the misinformation effect may not only reflect a change in performance at test, but also a change at the level of memorial representations. While many researchers assume that the misinformation effect is a measure of representational change, it has been argued elsewhere that this is not necessarily so (e.g., McCloskey & Zaragoza, 1985a; Schooler & Tanaka, 1991). This problem is more understandable when the basic misinformation paradigm is considered. What exactly is being manipulated? How does merely introducing inconsistent post-event information institute representational change?

Irrespective of whether the misinformation effect is due to destructive updating, blocking, retrieval failures, or alteration, *how* is the misinformation effect represented at the level of memorial representations? That is, what manipulation within the misinformation paradigm, before or during the introduction of misinformation, results in the original trace losing retrieval strength, or being altered, or blocked, etc? Current research into the role of retrieval inhibition in memory updating, however, may provide a novel account of why some misinformation effects occur. Observations from both the directed forgetting and retrieval-induced forgetting literature indicate that information that is subject to retrieval inhibition is no longer available to conscious inspection. If this is so, then retrieval inhibition may provide a

fairly natural explanation as to why misled participants appear so susceptible to misleading information. Simply put, if the original item is suppressed in memory through the actions of an inhibitory process, misled participants will have no choice but to rely on their memory for the misleading item.

Selective Retrieval in the Misinformation Paradigm

A potential role for retrieval inhibition in the production of misinformation effects becomes clearer when the post-event questionnaire in the typical misinformation paradigm is considered (e.g., E.F. Loftus et al., 1978). Many of these paradigms typically utilise post-event questionnaires to investigate the misinformation effect. The primary purpose of these questionnaires is to provide a medium for introducing misinformation without raising suspicions about the true nature of the experiment. This being so, the questions cannot be considered an exhaustive retrieval of information concerning the target event, that is the questions require the retrieval of only a sub-set of items from the target event. As it is the act of retrieving a sub-set of items from memory that elicits retrieval-induced forgetting (Anderson et al., 2000a), and that items need only be retrieved once in order for unpracticed items to be effectively inhibited (Macrae & MacLeod, 1999), the incomplete retrieval of items in the misinformation paradigm may lead to the inhibition of non-retrieved items as well. Thus, the retrieval practice and misinformation paradigms both involve the incomplete retrieval of information from memory. If misinformation was introduced about an item that had not been the subject of retrieval during questioning, then participants may be more likely to choose the misinformation on a recognition test because the original item had been inhibited in memory.

For example, following a critical question from Loftus et al. (1978): "Did another car pass the red Datsun while it was stopped at the stop sign?", participants are directed to retrieve information relevant to a possible second car, while the misinformation actually concerns the road sign. Thus, misled participants are not directed to retrieve information concerning the original critical item that the misinformation is introduced on. If no other questions involve the retrieval of information concerning the road sign, then the original sign (i.e., Yield sign) may be inhibited and unavailable for retrieval at testing time. In other words, when misled participants are asked what road sign was present within the original event, they would be more likely to choose a "Stop" sign than a "Yield" sign as the original "Yield" sign will be unable to compete for retrieval. This interpretation suggests that it is the post-event questionnaire that sets up the conditions necessary in order to produce the misinformation effect.

It should be noted, however, that the misinformation effect is not being advanced as merely an artefact of the paradigm. Irrespective of whether post-event questioning in the typical misinformation paradigm can inhibit information there remains important practical implications to this research as many police interviews are based on the selective retrieval of information about a witnessed event.

Conclusions from the Misinformation Effect

To summarise, the misinformation effect has provided a method for specifically examining how errors are made in memory through the reporting of contradictory information. Despite the misinformation effect also providing researchers with the opportunity to examine the underlying processes responsible for memory updating, this has largely been overlooked in favour of investigating questions concerning

memory permanence and the practical implications of post-event questioning. As such, a great deal of research has focused on whether information is permanently encoded in memory, thus suggesting that all information should be ultimately retrievable, or whether the encoding of newer information erases older memory traces. However, the similarities between the typical misinformation paradigm and the retrieval practice paradigm may provide an opportunity for investigating the role of retrieval inhibition in the misinformation effect. If this is indeed the case, a more thorough examination of the underlying mechanisms of the misinformation effect may be possible.

CHAPTER 5

EXPERIMENT 1a: RETRIEVAL-INDUCED FORGETTING AND
MISINFORMATION EFFECTS

The previous chapter reviewed research of the misinformation effect and concluded that the possible underlying mechanisms behind this effect have been largely ignored. Thus, while the majority of research has focused on questions concerning the permanency of information in memory, other fundamental questions related to how and why misinformation effects occur have been overlooked. This remains an important omission within the misinformation literature. Not only can an understanding of the memorial processes behind misinformation effects expand our knowledge of how memory errors and memory updating can occur, but we can also apply this knowledge to real world situations where misinformation can have an unwanted influence on our memories (e.g., eyewitness memory).

Answers to these questions might possibly be found in recent advances in memory research, which suggests that retrieval inhibition may play an important role in modulating the contents of our memories. As retrieval inhibition can be brought about through the retrieval process, this approach may be able to explain why individuals report misleading information, as well as alluding to the underlying mechanisms in memory behind the misinformation effect. The possibility that retrieval inhibition may be one of the missing mechanisms of the misinformation effect seems more likely given the similarities between the retrieval practice and misinformation paradigms.

The current chapter presents the preliminary stages of investigating a retrieval inhibition account of misinformation effects using a new paradigm that combines the

critical phases of the retrieval practice paradigm (typically used to examine retrieval-induced forgetting) with that of the misinformation paradigm. Before the exact nature of retrieval inhibition in the misinformation effect can be examined (i.e., is retrieval inhibition truly an example of an inhibitory processes or can it be explained by non-inhibitory processes?), the extent to which retrieval inhibition influences the misinformation effect must first be examined. As such, the following experiment examines whether retrieval-induced forgetting can provide an explanation for misinformation effects.

A New Method of Studying Misinformation Effects: The Modified Misinformation Paradigm

In order to examine the possible role of retrieval inhibition in the misinformation effect a modified misinformation paradigm was constructed. The critical phases of the retrieval practice and misinformation paradigms were combined into a five-stage paradigm, with additional distracter tasks. This meant that the initial study phase, retrieval practice phase, and recall phase from the retrieval practice paradigm were combined with later misinformation phases, specifically the post-event questioning phase and forced-choice recognition. The initial recall phase from the retrieval practice part of the new paradigm will allow retrieval-induced forgetting to be measured, while the forced-choice recognition test will allow misinformation effects to be measured. Thus, the modified misinformation paradigm proceeded in the following manner: presentation phase; retrieval practice phase; recall; misinformation phase; and forced-choice recognition.

The presentation phase introduced participants to the target material that was contained within two separate incidents in order to create a practiced category and an

unpracticed category. McCloskey and Zaragoza (1985a) have previously argued that the misinformation effect is partly due to the failure to encode information contained within the complex visual scenes contained within the slide sequences typically employed in misinformation studies. Taking this into consideration, written narratives were instead used. This presentation phase was followed by a retrieval practice phase that consisted of questions describing half of the items from one house. The effects of this retrieval practice was then measured in a recall task in order to measure whether participants demonstrated retrieval-induced forgetting before misinformation was introduced in the next phase. In this post-event questioning phase, each participant received a single piece of misleading information that was embedded in a question. These questions required participants to retrieve non-target information about the narratives read during the presentation phase. No target items were mentioned in this phase. The effect of introducing this misinformation was subsequently tested using a forced-choice recognition test.

Finally, an attempt was made to address McCloskey and Zaragoza's (1985a) argument that demand characteristics are inherent to typical misinformation paradigms. The primary basis of this argument centres on the fact that only a proportion of participants receive misleading information in the typical misinformation paradigm. As a result, the effects of demand characteristics are not equal across experimental and control conditions. The differential effect of demand characteristics in the modified misinformation paradigm was addressed through presenting misinformation to each participant.

Hypotheses

If the assumption that retrieval-induced forgetting influences the misinformation effect is correct then a number of specific predictions can be made. First of all, a larger misinformation effect is expected when post-event misinformation is introduced on items that have been subjected to retrieval-induced forgetting, and are therefore unavailable for retrieval. As individuals will be unable to bring these items into conscious awareness, participants are more likely to rely on their memory for the misleading item, an item that is available for retrieval. Thus, significant misinformation effects are expected when misleading information is introduced on *RP-items*. In contrast, the smallest misinformation effect is expected to occur when misinformation is introduced on items that have previously been practiced, and should therefore have been strengthened in memory. The strengthening of these items should make them much easier to retrieve, and thus easily brought to mind during the forced-choice recognition task. This being so, such items should be fairly resistant to misleading information, and very few participants should choose the misinformation when it is introduced on *RP+ items*. Similarly, items from the unpracticed category should also be fairly resistant to misleading post-event information because *NRP* items should not be subjected to retrieval-induced forgetting. As *NRP* items belong to a category that is unrelated to that of the practiced category, then they should not be subjected to retrieval-induced forgetting, and thus should remain available for retrieval. Therefore, significant misinformation effects are not expected when misleading information is presented on *NRP items*. Finally, in the *MisControl* condition where participants do not engage in relevant retrieval practice, none of the original items will be aided or impaired by previous practice, thereby producing a measure of the misinformation effect unaffected by retrieval-induced forgetting. We would expect,

therefore, that the misinformation effect should be of a similar size to that observed for NRP items.

Method

Participants and Design

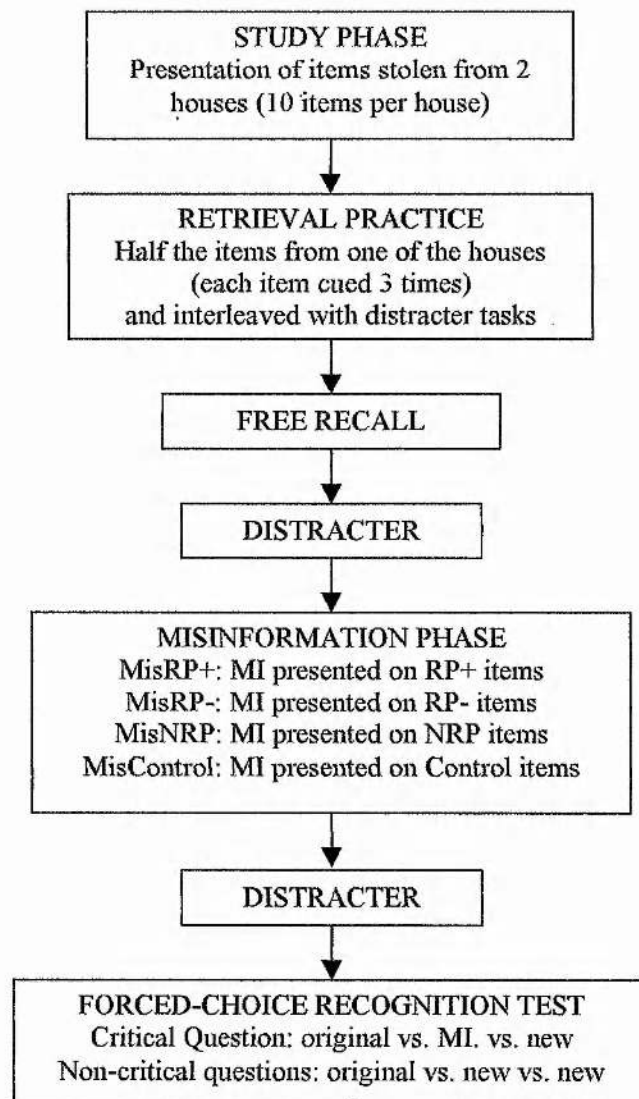
One hundred undergraduate students (42 males and 58 females) participated in this study on a voluntary basis. The experiment had a single factor (misinformation item: MisRP+, MisRP-, MisNRP, or MisControl) between-subjects design where post-event misinformation was introduced about either an RP+, or RP-, NRP, or Control item. The control condition acted as a between-subjects baseline where no relevant retrieval practice had taken place. Each condition contained 25 participants.

Materials

In order to examine the possible role of retrieval-induced forgetting in the production of misinformation effects, a new paradigm was constructed that combined critical phases from the typical retrieval practice paradigm (e.g., M.D. MacLeod, 2002; Shaw et al., 1995), and from misinformation paradigms (e.g., E.F. Loftus et al., 1978; McCloskey & Zaragoza, 1985a). The inclusion of phases from the retrieval practice paradigm permitted the assessment of retrieval-induced forgetting effects while the misinformation phases permitted the introduction of misinformation and the assessment of the misinformation effect. This new paradigm consisted of five major phases, with additional distracter tasks, and proceeded as follows: study phase; retrieval practice; free recall memory task; distracter; misinformation and additional

questioning phase; distracter; and forced choice recognition memory task (see Figure 21 for a summary of the experimental procedure).

Figure 21: Procedure used in Experiment 1a



Note. MI = misinformation. In the MisControl condition participants engaged in a non-relevant retrieval practice task that required them to retrieve the names of capital cities. All other phases within the MisControl condition were identical to the experimental conditions.

Study Materials

Study materials consisted of two booklets that described items stolen in two separate burglaries. The first page of each booklet contained a narrative that described where and when the incidents had occurred. One narrative concerned the theft of items from the Jones' house and described how the Jones' daughter had arrived home to find the house burgled. This narrative was followed by the description of ten items that had been stolen from the house (i.e., Game Boy, sunglasses, mobile phone, painting, binoculars, wristwatch, printer, television, coffee maker, china plate). Each item was presented embedded within a set of sentences describing where the stolen item had originally been located within the house, e.g., '*The television had been in the sitting room, which is at the front of the house. It was sitting in the corner of the room. The remote control for it hadn't been taken.*' Only the target item was underlined in order to emphasise that this was the stolen item. No attempt was made to match any of the items in terms of semantic similarity across households although some matching may have arisen simply as a function of creating two sets of stealable objects.

The second narrative concerned a burglary at the Smith's house that similarly detailed a number of items that had been stolen (i.e., computer, video recorder, telescope, rollerblades, necklace, Discman, camcorder, leather coat, crystal vase, microwave) and presented in the same manner. The stolen items were presented in blocked format (i.e., all items about the Jones' house followed by the Smith's house or *vice versa*) and their order within each block was fully randomised. The information sets for each house were divided into two subgroups (each containing five items) for the purpose of creating a practiced (i.e., RP+) and an unpracticed (i.e., RP-) set of items for each theft (see M.C. Anderson et al., 1994). The contents of

each sub-set were randomised for each participant (see Appendix A1 for both sets of narratives in their entirety).

Retrieval Practice Questions

Half of the items from one house formed a practice set (i.e., RP+ items) and the remaining items formed an unpracticed set (i.e., RP- items). Participants in the experimental conditions received fifteen retrieval cues in total that related to the same five items. Counterbalancing ensured that each of the items appeared equally often in the practiced and unpracticed categories. As previous work has suggested that increasing the difficulty of a retrieval task maximises practice effects (Landauer & Bjork, 1978), the level of question difficulty increased with each proceeding set of questions (see Appendix A2). The difficulty of each set of retrieval practice questions had been determined in earlier pilot work (cf. M.D. MacLeod, 2002). An independent group of participants ($n = 12$), who had not previously read either of the narratives, had been presented with questions from either Set 1 ($M = .96$), Set 2 ($M = .73$), or Set 3 ($M = .42$). Questions from Set 2 were determined to be significantly more difficult than questions from Set 1, $t(6) = 4.30, p < .01$, and Set 3 was determined to be significantly more difficult than Set 1, $t(6) = 24.07, p < .01$. Similarly, questions from Set 3 were found to be significantly more difficult than questions from Set 2, $t(6) = 5.66, p < .01$, see Appendix A3 for statistical tables. However, it is accepted that the effect prior knowledge may directly, or indirectly, impact on participant's ability to complete this task. As a result, the task may be more difficult, at least in part, for those participants in the pilot study who did not receive the original study materials compared to participants in the experiment who did receive the original study materials. Participants in the MisControl condition did not receive retrieval practice about any of

the stolen items. Rather, they received non-relevant retrieval practice (cf. Macrae & MacLeod, 1999) for the names of capital cities (e.g., the capital city of Cuba is Ha____; the capital city of Bulgaria is So____, etc), see Appendix A4.

Free Recall

A free recall task was employed as a manipulation check to determine whether retrieval-induced forgetting had occurred or not. The task required a written response and encouraged the recall of all items from both houses (see Appendix A5). It must, however, be noted that the recall of RP- and NRP items during this recall phase may change the retrieval status of these items (i.e., perhaps making them RP+ items).

Misinformation and Additional Questioning

Participants were presented with twelve additional questions about one of the burglaries. One of the questions contained a piece of misinformation about one of the stolen items presented in the original study phase (e.g., 'necklace' was replaced with 'earrings'), see Appendix A6 for a complete list of questions and misinformation items (eight misinformation items in total). Thus, depending upon treatment condition, participants received an erroneous piece of information about an RP+, or RP-, or NRP item. The misinformation item chosen was semantically related in each case to the critical item. All the questions used in this phase of the study referred to details that were neither the subject of the retrieval practice phase nor formed the basis of the final memory test. Participants in the MisControl condition also received a piece of misinformation about one of the thefts, thereby providing a baseline misinformation effect in the absence of relevant retrieval practice. Only one misinformation item was incorporated into each set of twelve questions so as not to arouse suspicions about the

nature of the study. In order to minimise possible item effects, four items in each household were selected as possible critical items against which semantically related misinformation would be introduced. The critical items chosen were counterbalanced throughout for each condition.

Forced-choice Recognition

The final test consisted of eight multiple-choice questions to test memory for the stolen items. Possible answers to each question comprised the originally presented item plus two erroneous items. The critical question that measured whether misinformation effects were present consisted of the original item, the misinformation item, plus one new wrong item (e.g., earrings vs necklace vs bracelet), see Appendix A7.

Procedure

Participants arrived at the laboratory individually or in groups of up to four and were randomly assigned to one of the testing conditions. Participants were informed that they would be taking part in a memory task and were instructed to read two narratives about two separate burglaries. The order of presentation of the two narratives was alternated between participants throughout the experiment. Information about the burglaries was contained within an experimental booklet that also contained a number of distracter tasks in addition to appropriate retrieval practice questions, and thus resembled the procedure outline in Shaw et al. (1995). Therefore, each retrieval practice set was followed by a five-minute distracter task. Participants were prompted through each phase of the booklet by the experimenter. Participants were informed that the underlined words represented the stolen items. Each item was presented on a separate page of the booklet. Participants were instructed to turn over to the next page

only on hearing an audible beep emitted by an electronic metronome (5-sec intervals). On completing the first narrative, participants were instructed to read the next narrative that concerned a burglary at the Smith's house.

Immediately after the study phase, participants in the experimental conditions were presented with a series of questions about one of the subsets of stolen items from one of the houses (thereby creating RP+, RP-, and NRP item sets). Following the final retrieval practice task, participants were required to perform a final distracter task which involved participants writing down the names of ten animals for each letter of the alphabet (see Appendix A8 for each task that was included within the retrieval practice booklet). Participants were given 5 minutes to accomplish this task. No participant successfully completed it within the time set. Following this, participants were instructed to recall all the items they could remember about both burglaries. Following recall, participants performed a further distracter task for two minutes (i.e., write down as many objects as possible that are black, wooden, blue, round and green for each letter of the alphabet, see Appendix A9). Again, no participant completed the task within the time allotted. Subsequent to this, participants were presented with twelve additional questions about one of the two burglaries and were given four-minutes to complete this task. Participants were then presented with a further distracter task in which participants were required to write down the names of ten countries for each letter of the alphabet (see Appendix A10). Five minutes were allotted to this task. No participant completed the task in the time allowed. The final test comprised eight multiple-choice questions that tested participants' memory for the stolen items. On completion of the recognition test, participants were debriefed, thanked for their participation and dismissed. (see Figure 21 for an outline of the procedure used).

Results

Retrieval Practice Success and Mean Recall Performance

The retrieval practice success rates for each of the experimental conditions were as follows: 90.6% ($SD = .11$), 88.8% ($SD = .08$) and 87.7% ($SD = .10$) for the MisRP+, MisRP- and MisNRP conditions respectively. Data displayed in Table 1 reveal that, across the various conditions, recall performance was .43 for unpracticed items from the unpracticed set, but only .26 for unpracticed items from the practiced set. This pattern suggests that retrieval-induced forgetting had occurred. Indeed, the magnitude of the difference in recall performance between RP- and NRP items ($-.17$) was comparable to that reported in other studies of retrieval-induced forgetting (e.g., M.C. Anderson et al., 1994; M.C. Anderson & Spellman, 1995; M.D. MacLeod, 2002, M.D. MacLeod & Macrae, 2001; Macrae & MacLeod, 1999).

Manipulation Check: Retrieval-induced Forgetting

MisRP+ Condition

A single factor (item type: RP+, or RP-, or NRP) within-subjects ANOVA revealed a significant main effect of item type for the MisRP+ condition, $F(2,48) = 79.13$, $p < .01$, $MSe = .04$. Cohen's f was calculated as an unbiased estimate of effect size (Cohen, 1988). This indicated the presence of a large effect for this condition (Cohen's $f = 1.81$). Using Holm's sequential Bonferroni approach to control for familywise error, a series of post-hoc paired samples t -tests indicated the presence of both facilitatory (i.e., $RP+ > NRP$, $t(24) = 8.34$, $p < .01$) and retrieval-induced forgetting effects (i.e., $RP- < NRP$, $t(24) = -2.70$, $p < .05$), see Appendix B1.

Table 1: Mean proportion recall as a function of item type

	Item Type			Retrieval-induced Forgetting
Condition	RP+	RP-	NRP	(RP-) – NRP
MisRP+	.85 (.12)	.25 (.19)	.40 (.23)	-.15
MisRP-	.82 (.17)	.27 (.13)	.44 (.18)	-.17
MisNRP	.83 (.17)	.26 (.15)	.46 (.16)	-.20
Mean	.83 (.15)	.26 (.15)	.43 (.19)	-.17

Note. RP+ items are practiced items from the practiced category. RP- items are unpracticed items from the practiced category. NRP items are items from the unpracticed category. MisControl condition ($M = .56$, $SD = .12$). Twenty-five participants were in each condition. Standard deviations are enclosed in parentheses.

MisRP- Condition

A single factor (item type: RP+, or RP-, or NRP) within-subjects ANOVA revealed significant effects of item type for the MisRP- condition, $F(2,48) = 85.01$, $p < .01$, $MSe = .02$. Calculations of effect size indicated the presence of large effects (Cohen's $f = 1.88$). Employing Holm's sequential Bonferroni approach, post-hoc paired samples t -tests revealed that participants recalled significantly more RP+ items than NRP items, $t(24) = 7.65$, $p < .01$, demonstrating the facilitatory effects of practice on recall.

Retrieval-induced forgetting effects were also detected with the recall of RP- items significantly lower than for NRP items $t(24) = -4.56, p < .01$ (see Appendix B2).

MisNRP Condition

A single factor (item type: RP+, or RP-, or NRP) within-subjects ANOVA revealed significant effects of item type for MisNRP, $F(2,48) = 67.10, p < .01, MSe = .03$. Calculations of effect size indicated the presence of a large effect (Cohen's $f = 1.68$). Using Holm's sequential Bonferroni approach, post-hoc paired samples t-tests revealed that participants recalled significantly more RP+ items than NRP, $t(24) = 6.47, p < .01$ (i.e., the presence of facilitatory effects). Similarly, recall performance for RP- items was found to be significantly lower than that for NRP items, $t(24) = -4.04, p < .01$, respectively (i.e., the presence of retrieval-induced forgetting effects). See Appendix B3.

Baseline Measures

A single factor between-subject ANOVA compared recall performance for NRP items in each condition with that of the MisControl condition to determine whether retrieval-induced forgetting was due to enhanced recall of NRP items. Recall of NRP items in the experimental conditions (overall $M = .43$) was found to actually be lower than for Control items ($M = .56$), $F(3, 96) = 4.01, p < .01, MSe = .03$, see Appendix B4. A series of independent t-tests confirmed that NRP recall performance in each experimental condition was significantly lower than the MisControl condition (MisRP+: $t(48) = -3.25, p < .01$; MisRP-: $t(48) = -2.85, p < .01$; MisNRP: $t(48) = -2.68, p < .01$. Thus, the observed difference between RP- and NRP recall

performance in all three experimental conditions is due to a real drop in the recall performance for RP- items rather than an enhanced recall for NRP items.

These manipulation checks serve to establish that, for all three experimental conditions, there are clear indications that the retrieval practice procedure has resulted in significantly poorer recall performance for the unpracticed items from the practiced set in comparison to the unpracticed items from the unpracticed set (i.e., $RP- < NRP$).

Misinformation Effects

Having demonstrated the presence of retrieval-induced forgetting in the three experimental conditions, we now turn to consider the effects of introducing misinformation about items that have been inhibited as a result of the retrieval practice procedure. The principal comparison of interest is between the level of misinformation effects in the MisRP- condition (i.e., where misinformation had been introduced about an item that is subjected to retrieval-induced forgetting) and where misinformation had been introduced about items that are not subjected to retrieval-induced forgetting (i.e., MisRP+, MisNRP and, MisControl conditions). Figure 22 indicates that when misinformation is introduced it has a larger effect on unpracticed items from the practiced set (MisRP-: 60% of participants chose the misinformation) than for Control items (24% of participants chose the misinformation). Similarly, misinformation has little effect on items that are not subjected to retrieval-induced forgetting (MisRP+: 16%; MisNRP: 20%; and, MisControl: 24%), see Table 2 for proportion of participants choosing the original, misinformation, or new item at test.

Thus, it would appear that items that are subjected to retrieval-induced forgetting are much more susceptible to post-event misleading information than items that are not subjected to retrieval-induced forgetting. Not only were participants in the

MisRP- condition two to four times more likely to choose the misinformation item than participants in other conditions, but they were also more than six times as likely to mistakenly choose the misleading item than to make an error on a non-critical item. In addition, participants in the MisRP- condition who failed to demonstrate a retrieval-induced forgetting effect ($n = 6$) reported the misleading item much less (17%) than participants who did demonstrate retrieval-induced forgetting (74%, $n = 19$).

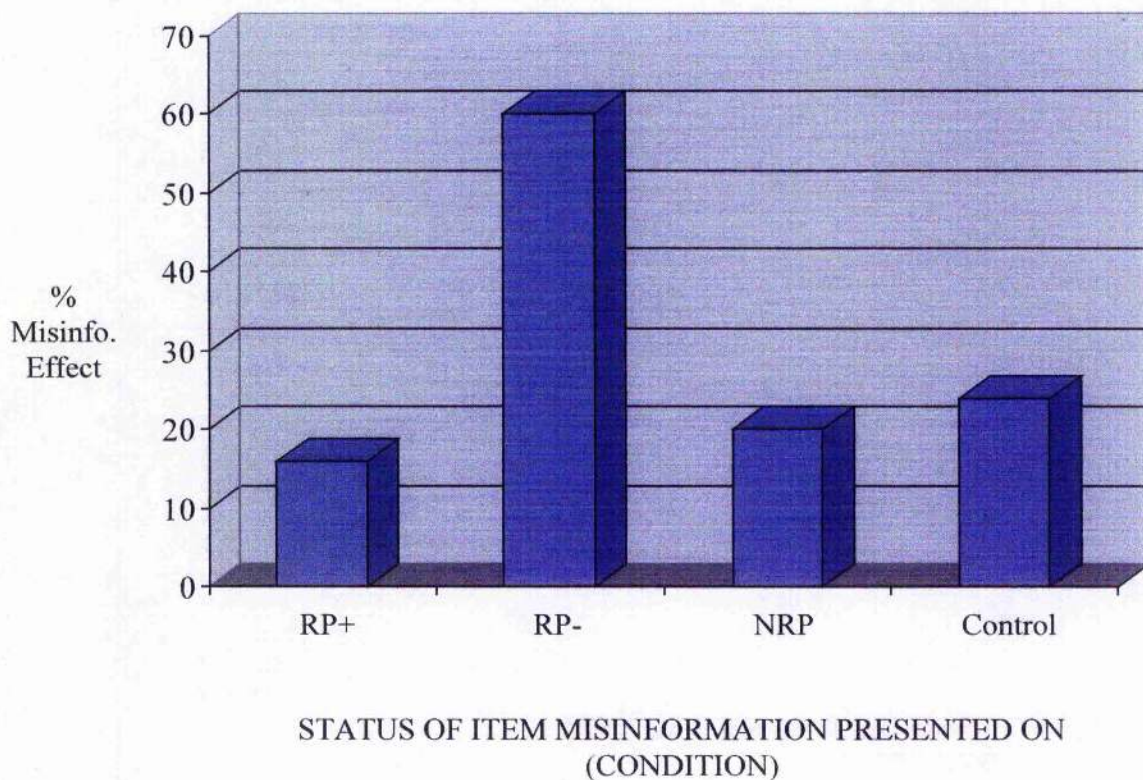
Table 2: Likelihood of participants choosing the original item, misinformation, and new erroneous item at forced-choice recognition.

Condition	Critical item			Non-critical items
	Original	Misinfo	New item	Mean Error
MisRP+	.84	.16	0	.15 (.17)
MisRP-	.40	.60	0	.11 (.16)
MisNRP	.80	.20	0	.14 (.18)
MisControl	.72	.24	.04	.09 (.13)

Note. MisRP+: where misinformation has been presented on an RP+ item. MisRP-: where misinformation has been presented on an RP- item. MisNRP: where misinformation has been presented on an NRP item. MisControl: where no relevant retrieval practice has occurred and misinformation has been randomly presented on items. For the critical question measuring the misinformation effect, participants had to choose from the correct original item, the misinformation, and a new erroneous item. Proportion of errors on non-critical items (i.e., original item vs. new item vs. new item) is also included as a baseline measure of the proportion of errors made at forced-choice recognition. Standard deviations are enclosed in parentheses.

A chi square analysis was conducted to evaluate whether misinformation had a more deleterious effect in conditions where misleading information was introduced on items that were subjected to retrieval-induced forgetting. Condition and misinformation effect were found to be significantly related, $\chi^2(3, n = 100) = 14.67$, $p < .01$ (see Appendix B5). Effect size was computed Phi ($\Phi = .38$), which indicated the presence of a medium sized effect.

Figure 22: Percentage of participants choosing the misinformation option during forced-choice recognition in Experiment 1a



Additional pairwise comparisons were conducted between the control and experimental conditions and revealed only one significant result. Participants in the MisRP- condition were significantly more likely to select misinformation than were participants in the MisControl condition, $\chi^2(1, n = 50) = 5.25, p < .05$. Effect size was computed using Phi ($\Phi = .32$), which indicated the presence of a medium-sized effect. In contrast, participants in the MisRP+ and MisNRP conditions reported the misinformation item as frequently as participants did in the MisControl condition (MisRP+: $\chi^2(1, n = 50) = .50, p = \text{n.s.}$; MisNRP: $\chi^2(1, n = 50) = .12, p = \text{n.s.}$). See Appendix B6 for statistical tables.

If the significant difference in reporting misinformation in the MisRP- and MisControl condition is due to the retrieval inhibition of original items in the MisRP- condition, then significant differences should also be present between this condition and the MisRP+ and MisNRP conditions. Pairwise comparisons confirmed that there were significantly more participants selecting misinformation in the MisRP- condition than in the MisRP+ condition, $\chi^2(1, n = 50) = 10.27, p < .01$, as well as the MisNRP condition, $\chi^2(1, n = 50) = .833, p < .01$. Effect sizes were also computed using Phi (MisRP+: $\Phi = .45$; MisNRP: $\Phi = .41$), indicating the presence of a medium-sized effect. See Appendix B7 for statistical tables. The non-significant effects for the MisRP+ and MisNRP conditions is also unlikely to be due to a lack of power given that the χ^2 values need to reach 3.84 in order to gain significance at 0.05.

There was also no significant difference in performance on the forced-choice recognition task across conditions for non-critical items (85%, 89%, 86% and 91% correct for the MisRP+, MisRP-, MisNRP and MisControl conditions respectively). Thus, it would appear unlikely that the misinformation effect produced in the MisRP- condition was due to poorer overall recall performance at time of test.

*Additional Analysis**Output Interference*

An alternative interpretation to the impaired recall in the experimental conditions must also be considered. It is possible that the decrease in the recall of RP- items is not due to retrieval-induced forgetting but is, in fact, due to output interference resulting from the use of a free recall procedure. As participants could recall items in any order they chose, participants may have recalled the strengthened RP+ items first, thus interfering with the recall of the unstrengthened RP- items. If the reduction in RP- performance is due to output interference then participants should only demonstrate retrieval-induced forgetting if they retrieved RP+ items early during free recall.

This possibility was examined using the procedure described in Macrae and MacLeod (1999) and M.D. MacLeod and Macrae (2001) for calculating output interference effects. Participants' recall performance was re-classified according to the extent to which they commenced their recall with RP+ items or RP- items (skipping NRP items). This was calculated by subtracting the mean recall position of RP+ items from the mean recall position of RP- items and then dividing the scores in two using a median split. The top half of this divide formed the early RP+ output group and the bottom half formed the early RP- output group. The retrieval-induced forgetting effect was then calculated for the early RP+ and early RP- output groups. If output interference significantly contributed to the pattern of forgetting, we could expect a bigger retrieval-induced forgetting effect in the early RP+ group in comparison to the early RP- group. Using a series of pairwise comparisons, no differences were found in the magnitude of the retrieval-induced forgetting effect in the early RP+ output group and the early RP- output group in any of the conditions, MisRP+ ($M = -.13$ vs. $-.15$), t

(23) = .11, n.s; MisRP- ($M = -.15$ vs. $-.19$), $t(23) = .46$, n.s; and MisNRP ($M = -.14$ vs $-.24$), $t(23) = 1.02$, n.s (see Appendix B8).

Decreased NRP Performance: I. Cross-Category Inhibition

Cross-category inhibition may also be a possible explanation of the decreased recall in the NRP baseline compared to the control baseline (an effect not typically found in studies employing non-relevant retrieval practice control conditions, e.g., Macrae & MacLeod, 1999) as both sets of items from each house share a degree of relatedness within each house, and across categories. Not only are the items all “stealable” but the items from each house are also described in the presentation phase as being ‘*stolen items from a household*’. In addition, items within each house and across categories share a degree of association with each other, which while not a direct one-to-one association, may have unintentionally caused cross-category inhibition. For example, the item *printer* in the Smith’s house is associated with *computer* from the Jones’ house, while *television* in the Smith’s house is associated with *video recorder* from the Jones’ house. It is possible that retrieving *printer* from the Smith’s house during the retrieval practice phase may not only have led to the intended inhibition of the unpracticed item *television* from the same house, but also the unintentional inhibition of *computer* and *video recorder* from the unpracticed Jones’ house as well.

While cross-category effects would explain the drop in the NRP baseline, and suggest that the presence of inhibitory processes may be affecting recall, it would make it unlikely that inhibition was also influencing the misinformation effect. This is because the level of reported misinformation effects in the MisNRP condition was equal to that reported in the MisControl condition, suggesting that the critical original items in the MisNRP condition were not inhibited. If cross-category inhibition was

present then some of the NRP items should have been subjected to the same inhibitory processes that are thought to suppress the recall of the RP- items. Therefore, the critical original NRP items would have been unavailable for retrieval and the level of misinformation effects should have been somewhere between that reported in the MisRP+ and MisControl conditions (i.e., where misinformation was introduced on non-inhibited items), and the MisRP- condition (i.e., where misinformation was introduced on inhibited items). If cross-category inhibitory effect were present, then the level of expected misinformation effects would have been somewhere between these two conditions because not every NRP item will have been subjected to inhibition. This is due to the randomisation of items in the retrieval practice phase for each participant, and because the association between items in each house was not a direct one-to-one match. Therefore, misinformation will have been introduced on an inhibited NRP item for only a proportion of participants in the MisNRP condition. For the remaining participants, misinformation will have been introduced on non-inhibited NRP items. However, as there were no significant differences in the level of misinformation effects in the MisRP+ and MisNRP conditions (.16 vs .20), this suggests that cross-category inhibition did not occur. This assertion is further supported by the finding of no differences between the levels of misinformation effects between the MisControl condition (.24), where no retrieval practice occurred and therefore no cross-category inhibition can occur, and the MisNRP condition (.20).

Therefore, in order to assess the claim that inhibitory processes facilitate the reporting of misinformation, it is first essential to demonstrate that cross-category inhibition is not present, and thus, the NRP items in the MisNRP condition are not subjected to inhibition. Most of all, it is critical that cross-category inhibition is not present in the MisNRP condition. In order to demonstrate this, participants' recall of

NRP items was divided into those NRP items that were associated or semantically similar to RP+ items (i.e., NRP-Similar items) and those items that were dissimilar (i.e., NRP-Dissimilar). The associations between the items from both houses were assessed by an independent reviewer (M.C. Anderson, see Appendix B9). A series of pairwise comparisons were performed that compared the recall of NRP-Similar items associated to RP+ items with the recall of NRP-Dissimilar items for each of the experimental conditions. The mean recall of NRP-Similar and NRP-Dissimilar items was as follows: MisRP+ condition ($M = .35$ vs $.37$), $t(24) = -.31$, $p = \text{n.s.}$; MisRP- condition ($M = .44$ vs $.36$), $t(24) = 1.10$, $p = \text{n.s.}$; and MisNRP condition ($M = .47$ vs $.39$), $t(24) = .95$, $p = \text{n.s.}$ (see Appendix B10). In line with M.C. Anderson and Spellman's (1995) findings of impaired recall of NRP items that are semantically similar to RP- items, a series of pairwise comparisons was conducted that considered difference in the recall of NRP items that were semantically similar to RP- items and NRP items that were semantically dissimilar. The mean recall of NRP-Similar and NRP-Dissimilar items was as follows: MisRP+ condition ($M = .41$ vs $.32$), $t(24) = 2.04$, $p = \text{n.s.}$; MisRP- condition ($M = .40$ vs $.41$), $t(24) = -.03$, $p = \text{n.s.}$; and MisNRP condition ($M = .58$ vs $.38$), $t(24) = 1.49$, $p = \text{n.s.}$ (see Appendix B11). Overall, there are no significant differences in the recall of NRP-Similar and NRP-Dissimilar within the experimental conditions and, most importantly, there is no evidence of cross-category inhibition operating within the MisNRP condition.

While there is no evidence of reliable cross-category inhibitory effects this does not constitute evidence that inhibitory processes do not underlie the reduced NRP performance present in the experimental conditions. Failure to demonstrate cross-category impairment in the NRP category may be due to nominal versus functional similarity (see M.C. Anderson & Spellman, 1995, for further details),

whereby there needs to be enough similar items on a list to highlight those similarities. As an item in one house was only associated with one item from the other house, it is unlikely that the similarities were salient enough for participants to be strongly influenced by them. This interpretation also fits with M.C. Anderson and Spellman's (1995) findings of cross-category inhibition with three semantically similar items in each category. It should also be noted that Experiment 1a was not designed *a priori* to investigate the role of cross-category inhibition in the misinformation effect. Thus, the materials, and the experimental design, did not control for the associations and semantic similarity between items.

II. Source Confusion

If cross-category inhibition cannot explain the decrease in NRP performance perhaps non-inhibitory processes can. Source confusion operates without the need to assert the presence of inhibitory processes and, as noted earlier, the items from each house share similarities with one another. In addition, the items are grouped into arbitrary categories (i.e., Smith's house and Jones' house were experimentally constructed categories that have no implicit meaning). Participants could easily have become confused over which house items belonged to and recalled items from the wrong house (e.g., mis-remembering items from the Smith's house as belonging to the Jones' house), thus leading to lowered NRP scores. However, the possibility of source confusion occurring can be discounted as participants were not cued to recall items in a specific order or from a specific house and the recalled items were coded as being correct regardless of which house they had belonged to.

III. Category Dropout

Another possible explanation of the low NRP recall in the delayed test condition is also based on the associations between item in both houses. Category dropout is a common finding in free recall tests. Recall performance in free recall tests follows a two-stage process whereby participants first recall a category and then recall the items within that category. Thus, recall performance can be poor for two reasons: the forgetting of whole categories, and the forgetting of individual items within each category. However, recall can be restored through the cueing of those categories (Tulving & Pearlstone, 1966; Rundus, 1971).

All of the items can fall into two equal-sized sub-categories: electrical and non-electrical goods. If all of the RP+ items come from one of these sub-categories then participants may benefit from having recently practiced items from that category leading to increased accessibility of that category (e.g., electrical items). This may increase the recall of electrical items in the NRP category while decreasing the recall of the non-electrical NRP items. Participants would also be more likely to suffer category dropout for the non-electrical set as these items represent a less coherent group of items (e.g., painting and binoculars have little common features) than the electrical items (e.g., computer and Discman have several common features). However, care was taken to ensure that RP+ sets did not solely constitute these kinds of sub-categories (i.e., practice sets consisted of both electrical and non-electrical goods that were randomly selected for each participant).

Despite this reasoning, the possibility that the decrease in NRP performance compared to the control baseline was due to category dropout was examined. The proportion of NRP items recalled for each sub-category (i.e., electrical and non-electrical goods) was calculated using pairwise comparisons: MisRP+ ($M = .38$ vs

.42), $t(24) = -.71$, $p = \text{n.s.}$; MisRP- ($M = .41$ vs .42, $t(24) = -.21$, $p = \text{n.s.}$ and; MisNRP ($M = .41$ vs .46), $t(24) = -.74$, $p = \text{n.s.}$ (see Appendix B12). Therefore, there appears to be no evidence of category dropout of electrical or non-electrical goods. Although it is possible that participants may have grouped the items into different smaller categories, the randomisation of retrieval practice sets for each participant and the small size of remaining sub-categories should have effectively reduced the likelihood of category dropout producing a significant effect on recall performance.

Discussion

The results from this study strongly indicate a potential role for retrieval-induced forgetting in the production of misinformation effects. In fact, the retrieval status of items appears to allow for predictions to be made with relative ease concerning the success of introducing misinformation. The introduction of misinformation was relatively unsuccessful in conditions where the original items were not subjected to retrieval-induced forgetting, thereby suggesting that the original items were freely available to conscious inspection. As such, participants were able to compare their memory for the original item from the study phase and the misleading item from the post-event questioning. Having compared these items, the majority of participants chose the original item.

In contrast, misinformation is more likely to be reported when it is introduced on an item that is subjected to retrieval-induced forgetting. Significantly more misinformation effects were found in the MisRP- condition than in any other condition. As alternative non-inhibitory explanations have been discounted as having played a significant role in the production of misinformation effects, a retrieval inhibition account can be considered. If this is indeed the case, then it is only RP-

items that are subject to retrieval inhibition, and as a result, it is only these items that should be unavailable to conscious inspection. As the RP- items are not available for retrieval, participants may be forced to rely on their memory for the misleading information from the post-event questioning.

The magnitude of the misinformation effect in the MisRP- condition is actually quite startling given that the RP-, NRP and MisControl items have been treated in the same manner. That is, participants only saw these items once during the study phase. Yet, there were around three times as many misinformation effects in the MisRP- condition compared to the MisNRP and MisControl conditions. The only difference between these three items is their relation to the practiced items: only the RP- items are drawn from the same category as items that underwent retrieval practice. As the goal of retrieval practice is to retrieve the RP+ items, RP- items were subjected to retrieval inhibition in order to prevent them from disrupting the preferential retrieval of the practiced items. As the RP- items were less available to conscious inspection, significant misinformation effects were only detected in the MisRP- condition.

In addition, the prior practice of items appeared not to garner any substantial protection from misleading information. Participants who received misinformation about an item that they had previously practiced mistakenly reported the misleading item at a similar level to that of participants who received misinformation about an NRP or Control item. Given that the retrieval of information is believed to strengthen those items in memory (e.g., Allen et al., 1969), evidenced by the increased recall of RP+ items compared to NRP and Control baseline recall, this finding of comparable misinformation effects in the MisRP+, MisNRP, and MisControl conditions is actually quite surprising. While a certain proportion of these misinformation effects

may be due to social factors (e.g., demand characteristics – the experimenter wrote the post-event questions and therefore must know what was contained within the narratives), it is also possible that the presence of retrieval inhibition plays a more influential role in an individual's vulnerability to misleading information. Specifically, the retrieval inhibition of an item may leave individuals more susceptible to misleading information in comparison to any increase in resistance to misinformation that is created through retrieval practice.

EXPERIMENT 1b: ENCODING CHECK

While retrieval-induced forgetting provides a compelling explanation of misinformation effects, it remains possible that participants only chose the misleading item because they never encoded the original item during the study phase. The non-retention hypothesis (cf. McCloskey & Zaragoza, 1985a) asserts that the misinformation effect is not the result of genuine memory impairment, and that the misleading item can only be integrated into event memory if the original item was never encoded. Thus, post-event misleading information merely acts as a piece of additional information, filling a gap in an individual's memory for an event. If true, therefore, it cannot inform us about the processes behind memory updating. In an attempt to address this concern, Experiment 1b examines whether participants encoded the information contained within the initial study phase.

Method

Participants

20 undergraduate psychology students participated in this experiment on a voluntary basis. Participants were tested individually.

Materials

Study Materials

As this experiment examined the possibility that misinformation effects may be due to participants failing to encode the target stolen item the materials used in the study phase of the current experiment were identical to those previously used in Experiment 1a.

Forced-choice Recognition

Memory for the stolen items was assessed using a forced-choice recognition test. There were twenty questions containing two possible correct answers (the correct item and an incorrect but novel item). Unlike in Experiment 1a, misinformation was not an option (see Appendix C).

Procedure

The procedure of Experiment 1b resembled the Control condition of Experiment 1a (i.e., no relevant retrieval practice) with the exception of the initial free recall and misinformation phases (which were replaced with additional distracter tasks). On arrival at the laboratory, participants were informed that they would be taking part in a memory task. Participants read two narratives about two houses that had been burgled and ten items had been stolen from each one. Participants then completed the

expanding retrieval practice schedule that control participants received in Experiment 1a. This task was followed by a name generation task whereby participants were cued to recall the name of an animal for each letter of the alphabet. After working on this task for five minutes participants were asked to work on a word generation task, in which they had to think of items that were black, made of wood, blue, round, and green, for two minutes (these tasks substituted the initial free recall task from Experiment 1a). Finally, participants were asked to recite the alphabet backwards for two minutes. No participant finished any of these tasks in the allocated time. On completion of these tasks participants were presented with another distracter task where they had to write down the names of ten countries for each letter of the alphabet. Participants worked on this task for nine minutes. Again, participants did not complete this task within the allocated time limit. Finally, participants were asked to complete a forced-choice recognition task that contained twenty multiple-choice questions about each of the stolen items. Participants had to choose the correct stolen item from a choice of the original item and one new incorrect item. On completion of this task, participants were thanked, debriefed and dismissed.

Results

The mean correct recognition of original items was calculated to determine how well participants had encoded the original information from the study phase. Mean recognition for all twenty original items was extremely high at 96.33% (s.d. = .04). This extremely high recognition rate was similar to recognition scores for non-critical items in the Control condition (91%) of Experiment 1a.

Discussion

In prior studies employing the typical misinformation paradigm, the possibility that misinformation effects were due to a failure to encode the original information always remained a strong possibility, especially given the highly complex nature of the visual materials used (McCloskey & Zaragoza, 1985a). The finding of intact recognition memory in the current experiment strongly indicates that individuals encoded information contained within the narratives of the study phase. As a result, the misinformation effects observed in Experiment 1a are unlikely to be due to any failure to encode the information.

Despite the importance that some researchers have attributed to the non-retention account (e.g., McCloskey & Zaragoza, 1985a), it can, however, only explain a proportion of misinformation effects using the typical misinformation paradigm. It is unlikely that a significant proportion of participants would fail to encode the original item, or to forget those items during a retention interval. However, the non-retention account, in combination with the possible effects of demand characteristics and guessing, continues to provide a strong argument against memory impairment accounts. Fortunately, as each participant receives misinformation in the modified misinformation paradigm, demand characteristics and guessing rates should be approximately equal across conditions, and so cannot account for the varying success of misleading information. The finding in Experiment 1b that participants not only encode the target items during the study phase, but that they also retain them in memory across the experimental session until final test, further supports a memory impairment account (and specifically a retrieval inhibition account) rather than McCloskey and Zaragoza's (1985a) non-cognitive explanations.

As significant misinformation effects were only found in the MisRP- condition in Experiment 1a it suggests that a possible boundary condition of the misinformation effect is retrieval availability of the original item. The results of Experiment 1a suggest that the original item may need to be unavailable for conscious inspection in order for misinformation to take effect. The retrieval inhibition account of the misinformation effect was further supported by the finding that participants in the MisRP- condition who demonstrated retrieval-induced forgetting were over four times as likely to choose the misleading item (fourteen of nineteen participants = 74%) than participants who failed to demonstrate retrieval-induced forgetting (one of six participants = 17%). These two findings suggest that the presence of retrieval inhibition may greatly facilitate the misinformation effect. If this is indeed the case, then significant misinformation effects should only be found when retrieval inhibition is present. This prediction can be tested in several ways, either through varying the presence of retrieval-induced forgetting within a condition, as well as manipulating the retrieval status of a specific item (e.g., RP- or RP+). Experiment 2 tests the former prediction by varying the length of the retention interval between study and retrieval practice, and between retrieval practice and test, in order to see whether the dissipation of retrieval-induced forgetting has an effect on the misinformation effect.

CHAPTER 6

EXPERIMENT 2A: THE DISSIPATION OF RETRIEVAL-INDUCED
FORGETTING WITH DELAYED TESTING

Research has previously highlighted the goal-directed nature of forgetting in social cognition (Macrae & MacLeod, 1999; M.D. MacLeod & Macrae, 2001), suggesting that the retrieval inhibition of unwanted information should only be present so long as it satisfies current memorial goals. If this assumption is correct, then in order for retrieval-induced forgetting to serve an adaptive role in memory it may be necessary for its effects to be relatively short-lived. For example, when an individual is asked for their home postcode, the retrieval efficiency and retrieval speed of that information would be increased if all prior home postcodes could be suppressed. However, there would be little adaptive benefit in permanently erasing previous postcodes due to the possibility that this information may be required at a later date (e.g., previous postcodes can sometimes be required in order to open a bank account).

Thus, the temporary inhibition of competing information may allow our memory systems to be able to adapt to the rapidly changing goal states that characterise everyday memory (Bodenhausen & Macrae, 1998; Macrae & Bodenhausen, 2000). In line with this assumption, M.D. MacLeod and Macrae (2001) have previously demonstrated that under certain conditions retrieval-induced forgetting is a temporary phenomenon. Specifically, M.D. MacLeod and Macrae found that retrieval-induced forgetting dissipated when a 24-hour delay was inserted between retrieval practice and final recall.

Similarly, as there are unlikely to be many real world situations in which retrieval practice occurs directly after encoding, retrieval inhibition must be able to

act on old and newly encoded memories alike for it to be considered an adaptive forgetting process. M.D. MacLeod and Macrae (2001) investigated this potential constraint on the retrieval-induced forgetting effect by inserting a 24-hour delay after encoding but before retrieval practice. A reduced, but significant, retrieval-induced forgetting effect was still evident under these conditions, suggesting that the effect is not constrained by the age of the memory. This finding was also reported by Koutstaal et al. (1999) using a two-day delay.

The current chapter further considers the role of delay on retrieval-induced forgetting, and its effect on the misinformation effect. Experiment 2a attempts to replicate the delayed test condition from M.D. MacLeod and Macrae (2001, Experiment 1) using material from Experiment 1a in order to determine whether retrieval-induced forgetting will dissipate over a 24-hour delay. Following this groundwork, Experiment 2b examines the effects of the possible temporary boundary condition (delayed test and delayed practice) on the misinformation effect.

Hypotheses

Following on from the prior work by M.D. MacLeod and Macrae (2001) concerning the effects of delay on retrieval-induced forgetting, two main predictions can be made concerning the current study. As there is a 24-hour delay between retrieval practice and final test in the Delayed Test condition retrieval-induced forgetting effects are not expected. In contrast, as there is no delay between retrieval practice and final test in the Immediate Test condition the retrieval-induced forgetting effect is expected.

Method

Participants and Design

Sixty undergraduate students (12 males and 48 females) participated on a voluntary basis in this experiment. The study had a single factor (recall test: immediate or delayed) between-subjects design. The Immediate Test condition consisted of presentation, retrieval practice and free recall. The Delayed Test condition followed this format with the insertion of a 24-hour delay between the retrieval practice and free recall phases. Each condition contained 30 participants.

Materials

Study Materials

The study materials in the presentation phase were identical to those used in Experiment 1 (see Appendix A1).

Retrieval Practice Questions

The retrieval practice questions were identical to those used in Experiment 1 (see Appendix A2).

Free Recall

A free recall task was employed to determine whether retrieval-induced forgetting had occurred or not. The task required a written response and encouraged the recall of all items from both houses.

Procedure

Participants arrived at the laboratory individually or in groups of up to four and were randomly assigned to one of the testing conditions where either a 24-hour delay occurred prior to final recall, or where no such delay occurred. Instructions to participants, retrieval practice procedures, distracter tasks, and the free recall test were identical to those used in the retrieval practice half of Experiment 1a (see Appendix A8 for distracter tasks). As in the previous studies, no participant completed any of the distracter tasks. On completion of the final recall task, participants were debriefed, thanked for their participation, and dismissed.

Results

Retrieval Practice Success and Mean Recall Performance

Retrieval practice success was 92% ($SD = .09$) for the Immediate Test condition, and 86% ($SD = .11$) for the Delayed Test condition. In the Immediate Test condition, the mean recall of RP+ items was .87, .41 for RP- items, and .54 for NRP items. In the Delayed Test condition, recall of RP+, RP-, and NRP items was .37, .32, and .35 respectively (see Table 3), thereby confirming M.D. MacLeod and Macrae's (2001, Exp. 1) results of the effect of delay on retrieval-induced forgetting.

Transformation of Data

The recall scores (proportion correct) within each condition were transformed using arcsin transformation in order to establish homogeneity of variance for all subsequent analyses (see Snedecor & Cochran, 1980, pp. 290-291).

Table 3: Mean performance as a function of item status

Condition	Item Type			Retrieval-induced Forgetting
	RP+	RP-	NRP	(RP-) – NRP
Immediate Test	.87 (.15)	.41 (.25)	.54 (.18)	-.13
Delayed Test	.37 (.17)	.32 (.14)	.35 (.16)	-.03

Note. RP+ items are practiced items from the practiced category. RP- items are unpracticed items from the practiced category. NRP items are items from the unpracticed category. Standard deviations are enclosed in parentheses.

Retrieval-induced Forgetting

Immediate Test Condition

A single factor (item type: RP+, RP- or NRP) within-subjects ANOVA revealed a significant effect of item type on recall performance, $F(2,58) = 57.03$, $p < .01$, $MSe = .09$. Calculations of effect size indicated the presence of a large effect ($f = .89$). A series of pairwise comparisons using Holm's sequential Bonferroni approach to control for familywise error revealed that significantly more RP+ items were recalled compared to NRP items, $t(29) = 6.84$, $p < .01$, demonstrating the facilitatory effects of practice on memory performance. In addition, significantly fewer RP- items were recalled compared to NRP items, $t(29) = -2.06$, $p < .05$, revealing the detrimental effects of the retrieval of related information on memory performance (see Appendix D1 for statistical tables).

Delayed Test Condition

A single factor (item type: RP+, RP- or NRP) within-subjects ANOVA revealed no significant effect of item type on memory performance, $F(2,58) = .93$, $p = \text{n.s.}$, $MSe = .03$, $f = .03$ (see Appendix D2 for statistical tables). This absence of retrieval-induced forgetting effects after a substantial retention interval thereby confirms M.D. MacLeod and Macrae's (2001) previous findings.

*Additional Analysis**Output Interference*

Using the procedure outlined in Experiment 1a, the possibility that the retrieval-induced forgetting effect found in the Immediate Test condition was due to output interference was examined. As the previous practice of RP+ items leads to these items becoming more accessible in memory, participants may recall these items first decreasing the chances of the weaker RP- items being recalled. The retrieval-induced forgetting effect was calculated for the early RP+ and early RP- output groups in the Immediate Test condition (cf. Macrae & MacLeod, 1999). A pairwise comparison revealed that there was actually a stronger retrieval-induced forgetting effect in the early RP- output group ($M = -.26$) than the early RP+ group ($M = -.07$), $t(28) = 2.37$, $p < .05$ (see Appendix D3 for statistical tables). This effect was contrary to what would have been predicted if output interference had significantly contributed to the observed effect.

Decrease in NRP Performance

I. Cross-category Inhibition

A series of pairwise comparisons were conducted to determine whether cross-category inhibition was present. This analysis is critical due to the absence of a no retrieval-practice control baseline condition in the current series of experiments (due to the main manipulation being delay). It is necessary to demonstrate that the NRP baseline is a relatively pure measure of the recall of unpracticed items from an unpracticed category and that this measure has not been contaminated by the retrieval activity of items in the retrieval practice set. This was accomplished following the same procedure as outlined in Experiment 1a. No significant differences were detected between NRP-Similar to RP+ items and NRP-Dissimilar to RP+ items in the Immediate Test condition ($M = .38$ vs $.43$), $t(29) = -.75$, $p = \text{n.s.}$ (see Appendix D4 for statistical tables). A separate set of pairwise comparisons examined the recall of NRP items that were similar to RP- items (i.e., NRP-Similar) and NRP items that were dissimilar (i.e., NRP-Dissimilar) in the Immediate Test condition ($M = .43$ vs $.39$), $t(29) = .69$, $p = \text{n.s.}$ (see Appendix D5 for statistical tables). Thus, there was no consistent impairment of NRP-Similar items that were associated with RP+ or RP- items.

II. Category Dropout

As in Experiment 1a, all of the items can potentially fall into two broad categories: electrical and non-electrical items. Therefore, category dropout may be a factor in both the loss of the retrieval-induced forgetting effect, and the practice effect, in the Delayed Test condition, or the retrieval-induced forgetting effect in the Immediate Test condition. Participants in the Immediate Test condition may benefit from having

recently practiced items from the electrical or non-electrical sub-set leading to increased accessibility of that category (e.g., electrical items). This may increase (or decrease) the likelihood of electrical items in the NRP category being recalled and lead to an increase in NRP items in the Immediate Test condition. Thus, the retrieval-induced forgetting effect might be explained entirely by category dropout. Participants in the Delayed Test condition would not benefit from this increase in accessibility of sub-categories due to the retrieval practice phase occurring before the delay and would suffer from the dropping out of categories. Participants would also be more likely to suffer category dropout for the non-electrical set as these items represent a less coherent group of items (e.g., painting and binoculars have little common features). If, on the other hand, participants were cued with the sub-categories, the recall of NRP items would be restored and may reveal RP- impairment that was otherwise masked by category dropout. However, care was taken to ensure that RP+ sets did not constitute solely these kinds of sub-categories (i.e., practice sets consisted of both electrical and non-electrical goods that were randomised for each participant).

Despite this reasoning, the possibility that fluctuations in the recall of NRP items may be due to category dropout was examined. The proportion of NRP items recalled for each sub-category (i.e., electrical and non-electrical goods) was calculated using pairwise comparisons: Immediate Test ($M = .49$ vs $.54$), $t(29) = -.73$, $p = \text{n.s.}$; and; Delayed Test ($M = .29$ vs $.33$), $t(29) = -.78$, $p = \text{n.s.}$ (see Appendix D6 for statistical tables). Therefore, there appears to be no evidence of category dropout of electrical or non-electrical goods. As in Experiment 1a, it remains a possibility that participants may have grouped the items into different smaller categories. However, the randomisation of retrieval practice sets for each participant, and the small size of

remaining sub-categories should have reduced the likelihood of category dropout producing any significant effect on recall performance.

Discussion

The results of the current study support the previous findings by M.D. MacLeod and Macrae (2001) that retrieval-induced forgetting can be a transitory forgetting process. When recall is delayed by a substantial retention interval, retrieval-induced forgetting is found to be absent while, in contrast, a significant retrieval-induced forgetting effect was evident when memory was tested immediately. Retrieval-induced forgetting may dissipate due to memory having sufficient time to adapt to the change in the goal of the experiment. That is, during retrieval practice, the goal of the task is to retrieve the target RP+ items as quickly and as accurately as possible in response to a set of questions, and that this is achieved through the suppression of unwanted but related information that may compete for retrieval with target items. However, at final recall, the goal changes and participants must try to recall all items. Under conditions where this test immediately follows retrieval practice, the retrieval-induced forgetting of the competing items continues to influence the recall of information. In contrast, if a long delay occurs directly after the retrieval practice task, retrieval-induced forgetting dissipates and the previously suppressed items become available for retrieval. Thus, participants are able to satisfy the new goal of the final recall task.

However, although retrieval-induced forgetting was found to have dissipated after a delay following retrieval practice, no strong recovery in RP- recall was observed. In fact, recall for all item types was found to be quite poor. While it could be argued that the RP- items actually remained inhibited, and the absence of retrieval-induced forgetting is entirely the result of a drop in the NRP baseline, there are other

factors to consider that do not support this interpretation. First of all, M.D. MacLeod and Macrae (2001) did find a slight recovery in recall for RP- items without any significant drop in the NRP baseline, suggesting that the RP- items did indeed recover from a prior state of inhibition. Given this slight recovery, it may require a longer delay in order for the recall of RP- items to reach that of the NRP items.

Secondly, the recovery in RP- items can not only be measured by the ability to recall RP- items, but also in terms of the extent to which these items can interfere with the retrieval of RP+ items. As retrieval-induced forgetting is believed to be a method of resolving competition at retrieval, if those competing RP- items were again made available for retrieval they could be expected to compete and interfere with the retrieval of RP+ items. This possibility may have actually been observed during the current study as recall performance for RP+ items decreased after the 24-hour delay following retrieval practice. Thus, this inability of participants to recall the previously practiced items may have been due to the related RP- items becoming available to conscious inspection and interfering with the retrieval of RP+ items.

A third finding that would not support the poor performance account of the dissipation of retrieval-induced forgetting would be if significant misinformation effects were only found in conditions where retrieval-induced forgetting was found to still be present. Experiment 1a suggests that participants who exhibit retrieval-induced forgetting are more likely to report the misleading item than are participants who do not demonstrate retrieval-induced forgetting. In order to examine this possibility in further detail, the following experiment seeks to examine the effects of delay on the production of misinformation effects.

EXPERIMENT 2B: THE EFFECTS OF DELAYED TESTING AND DELAYED PRACTICE ON THE MISINFORMATION EFFECT

The results of Experiment 1a suggest that the presence of retrieval-induced forgetting may be a necessary condition in the production of the misinformation effect. Not only were significant misinformation effects only found in the condition where misinformation was introduced on RP- items but this effect was most noticeable when participants also demonstrated retrieval-induced forgetting. Therefore, the presentation of misinformation about an RP- item in itself appears to be insufficient to produce misinformation effects: participants must also exhibit retrieval-induced forgetting. These two boundary conditions suggest that the RP- item must be unavailable for retrieval, and unable to compete with the misinformation at test.

The current study further examines these possible boundary conditions of the misinformation effect by manipulating the presence of retrieval-induced forgetting through the insertion of a substantial delay between retrieval practice and final recall. The current study also examines whether the misinformation effect is constrained by the age of the initial memory and this is accomplished through the insertion of a delay between the study and retrieval practice phases.

Hypotheses

If retrieval-induced forgetting and the retrieval inhibition of the RP- items are necessary conditions for the production of the misinformation effect, then significant misinformation effect should only be found when retrieval-induced forgetting is present. Under such condition, the RP- items should be unavailable for conscious inspection at both the time of misinformation exposure, as well as at the time of test,

in order for the misinformation effect to occur. If retrieval-induced forgetting dissipates when a substantial delay occurs after retrieval practice, as evidenced by Experiment 2a of the present thesis and M.D. MacLeod and Macrae (2001), then the release of retrieval inhibition for RP- items should allow retrieval access to those items. As the critical RP- item will be available to conscious inspection it will be able to compete with the misinformation at forced-choice recognition. Given a choice at test between the original critical item, the misinformation, and a new item, participants are likely to choose the original item. However, if a delay of similar length occurs after encoding, but before retrieval practice, both retrieval-induced forgetting and misinformation effects can be expected. While retrieval-induced forgetting may be reduced due to some degrading of the original event over the delay, the effect will remain sufficiently strong for RP- items to be unavailable for retrieval during the presentation and testing of misinformation.

Method

Participants and Design

Ninety undergraduate students (37 males and 53 females) participated on a voluntary basis in this study. The experiment had a single factor (timing of delay: No Delay, Delayed Practice, or Delayed Test) between-subjects design. The main phases of the No Delay condition comprised a presentation phase, retrieval practice, free recall, misinformation and additional questioning phase, and a forced-choice recognition test. The Delayed Practice condition followed this format with the inclusion of a 24-hour delay between the presentation and retrieval practice phases. For the Delayed

Test condition, this 24-hour delay occurred between the retrieval practice and free recall phases. Each condition contained 30 participants.

Materials

Study Materials

The study materials used in the presentation phase were identical to those used in Experiment 1a (see Appendix A1).

Retrieval Practice Questions

The retrieval practice questions were identical to those used in Experiment 1 (see Appendix A2).

Free Recall

A free recall task was employed as a manipulation check to determine whether retrieval-induced forgetting had occurred or not. The task required a written response and encouraged the recall of all items from both houses.

Misinformation and Additional Questioning

The additional questions used in this phase were identical to those used in Experiment 1a (see Appendix A6). However, unlike this previous study, misinformation was only presented on RP- items.

Forced-choice Recognition

This recognition test was identical to that used in Experiment 1a (see Appendix A7).

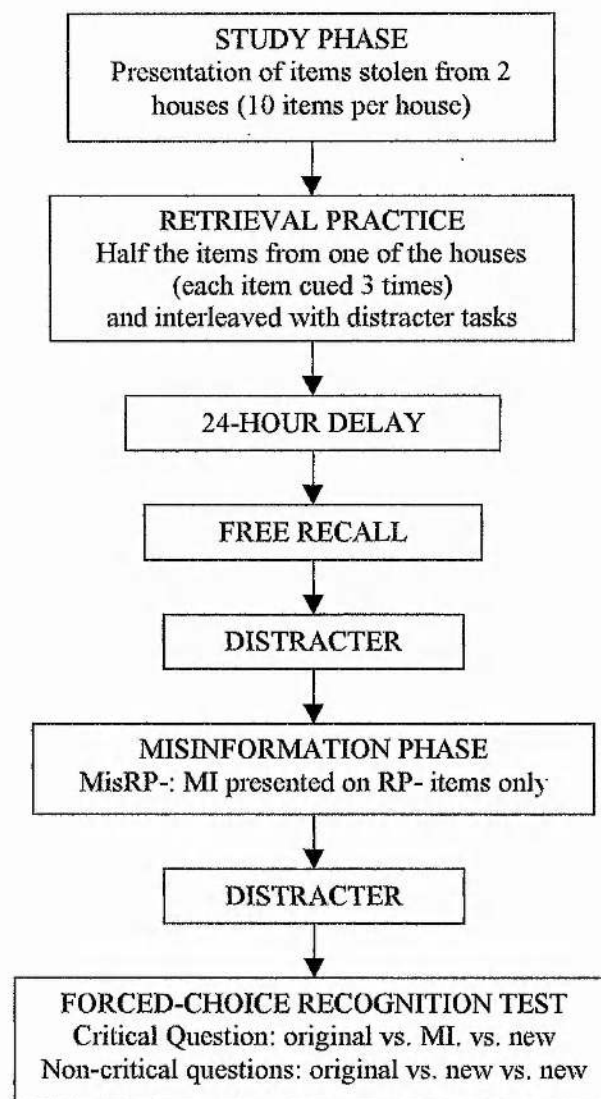
Procedure

Participants arrived at the laboratory individually or in groups of up to four and were randomly assigned to one of the conditions. Instructions to participants, retrieval practice procedures, filler tasks, free recall test, additional questioning procedure, and forced-choice recognition test were all identical to those used in Experiment 1a. As in the previous studies, no participant completed any of the distracter tasks. On completion of the forced-choice recognition test, participants were debriefed, thanked for their participation, and dismissed (see Figure 23 for an outline of the procedure for the Delayed Test condition, and Figure 24 for an outline of the procedure for the Delayed Practice condition).

Results

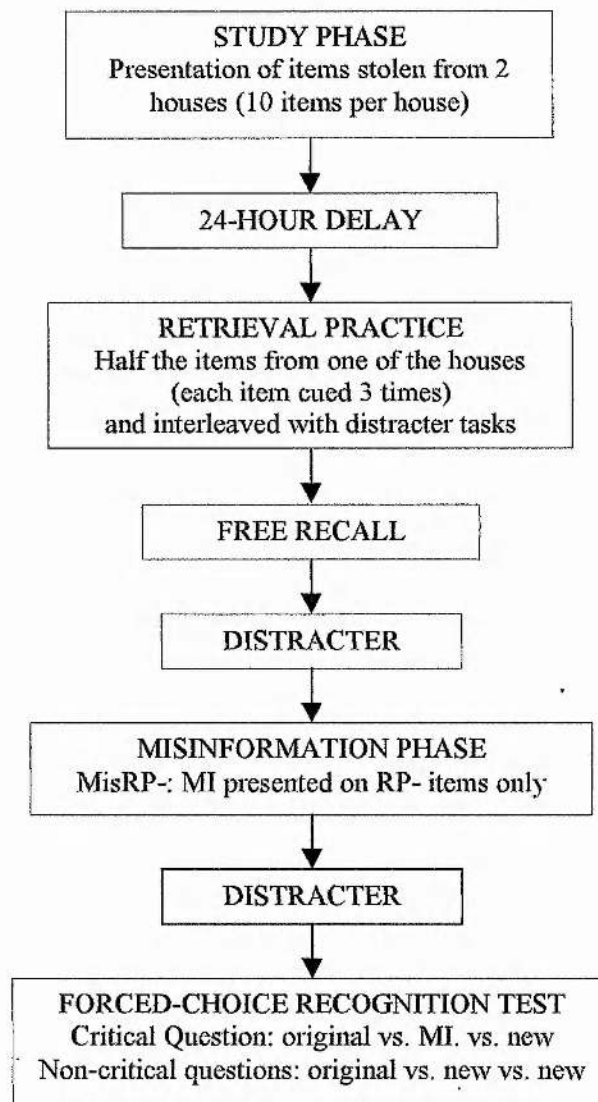
Retrieval Practice Success and Mean Memory Performance

The retrieval practice success rate was 86.7% ($SD = .08$), 88.4% ($SD = .12$) and 88.2% ($SD = .07$) in the Delayed Test, Delayed Practice, and No Delay conditions respectively. Mean recall of the three item types in conditions where retrieval-induced forgetting was predicted (i.e., no delay and delayed practice conditions) was .83 for RP+ items, .37 for RP- items, and .51 for NRP items (see Table 4 for recall performance for individual item types in each condition). This difference of +.32 between practiced items and the unpracticed baseline confirms the facilitatory effect that practice has on memory performance. However, the prior retrieval of items also had a deleterious effect on related items in the no delay and delayed practice conditions. A mean difference of -.14 was calculated between the RP- and NRP items indicating the presence of strong retrieval-induced forgetting effects.

Figure 23: Procedure for Delayed Test condition

Note. MI = misinformation

Figure 24: Procedure for the Delayed Practice condition



Note. MI = misinformation

In contrast, no practice or retrieval-induced forgetting effects were detected in the Delayed Test condition. Recall of RP+ items (.33) was only slightly greater than that of the NRP items (.29), an improvement of only +.04. Similarly, recall of RP- items (.33) was slightly higher than recall for the NRP items (.29).

Transformation of Data

The recall scores (proportion correct) within each condition were transformed using arcsin transformation in order to establish homogeneity of variance for all subsequent analyses (see Snedecor & Cochran, 1980, pp. 290-291).

Table 4: Mean recall performance as a function of item type

	Item Type			Retrieval-induced Forgetting
Condition	RP+	RP-	NRP	(RP-) – NRP
Delayed Practice	.80 (.17)	.37 (.26)	.51 (.18)	-.14
No Delay	.85 (.14)	.37 (.26)	.50 (.18)	-.13
Delayed Test	.33 (.22)	.33 (.21)	.29 (.17)	+.04

Note. RP+ items are practiced items from the practiced category. RP- items are unpracticed items from the practiced category. NRP items are items from the unpracticed category. Standard deviations are enclosed in parentheses.

*Manipulation Check: Retrieval-induced Forgetting**No Delay*

A single factor (item type: RP+, or RP-, or NRP) within-subjects ANOVA revealed main effects for item type, $F(2,58) = 50.86$, $p < .01$, $MSe = .04$, and this effect size was large ($f = 1.32$). Familywise error was controlled for in a series of pairwise comparisons by using the Holm's sequential Bonferroni approach and revealed that significantly more RP+ items were recalled compared to NRP items, $t(29) = 7.93$,

$p < .01$, confirming the positive impact prior retrieval has on subsequent memory performance. Pairwise comparisons also confirmed the presence of significant retrieval-induced forgetting effects in this condition with significantly fewer RP- items recalled than NRP items, $t(29) = -2.55$, $p < .05$ (see Appendix D7 for statistical tables).

Delayed Retrieval Practice

A single factor (item type: RP+, or RP-, or NRP) within-subjects ANOVA revealed main effects of item type, $F(2,58) = 30.41$, $p < .01$, $MSe = .05$. Calculations of effect size revealed the presence of a large effect ($f = 1.02$). A series of pairwise comparisons using Holm's sequential Bonferroni approach confirmed the facilitatory effects on memory performance of prior practice with significantly more RP+ items reported than NRP items, $t(29) = 5.84$, $p < .01$. Fewer RP- items were also recalled compared to NRP items, $t(29) = -2.38$, $p < .05$, thereby confirming that retrieval-induced forgetting had taken place (see Appendix D8 for statistical tables).

Delayed Test

Using a single factor (item type: RP+, or RP-, or NRP) within-subjects ANOVA no significant effects of item type were found in the Delayed Test condition, $F(2,58) = 0.44$, $p = \text{n.s.}$ (see Appendix D9 for statistical tables). The failure of retrieval practice to have a significant impact on the recall of any of the item sub-sets replicates the findings from the Delayed Test in experiment 2a and confirms the findings from the Delayed Test in M.D. MacLeod and Macrae (2001, Exp. 1).

The results of these manipulation checks in the Delayed Test condition are consistent with the idea that retrieval-induced forgetting effects are transitory in nature

(M.D. MacLeod & Macrae, 2001). If a 24-hour delay occurs between retrieval practice and recall then retrieval-induced forgetting effects are not detected. Thus, if a sufficiently long delay is inserted after practice then any retrieval-induced forgetting of RP- items resulting from retrieval practice will dissipate. In contrast, when a 24-hour delay occurs between presentation and retrieval practice, retrieval-induced forgetting effects remain evident.

Misinformation Effects

The results of Experiment 1a suggest that it is the 'inhibitory' state of an item that governs the success of introducing misinformation on a critical original item. In Experiment 1a, misinformation was easily introduced on inhibited items (i.e., RP- items), but not on non-inhibited information (i.e., RP+, NRP, or control items). Extending this line of enquiry, misinformation should only be successfully introduced on a critical original item that is *currently* inhibited and, is thus, unavailable for conscious inspection. If the presence of retrieval-induced forgetting in this manner is an essential boundary condition, then significant misinformation effects are only expected in conditions where retrieval-induced forgetting is demonstrated (i.e., No Delay and Delayed Practice conditions). In contrast, if retrieval-induced forgetting has dissipated then the original item should be available in memory and thus misinformation is expected to have little effect on participant's memory for an event. Under these conditions, where retrieval-induced forgetting is absent (i.e., Delayed Test condition), only low levels of misinformation effects are expected. Thus, in order to examine the effects of delay on the misinformation effect, the proportion of misinformation effects in the No Delay and Delayed Practice conditions were compared with the Delayed Test condition.

As expected, misinformation effects were greatest in conditions where retrieval-induced forgetting was still present, with 50% of participants choosing the misinformation in the No Delay condition and 57% in the Delayed Practice condition (see Figure 25). Misinformation effects were lowest in the Delayed Test condition where retrieval-induced forgetting effects were absent (see Table 5 for proportion of participants choosing the original, misinformation, or new item). Only 20% of participants in this condition chose the misinformation over the critical original item. These differences were confirmed with chi square analysis. Misinformation had a greater effect in conditions where retrieval-induced forgetting was present and the critical original item was still inhibited, $\chi^2(1, n = 60) = 5.93, p < .01$, $\chi^2(1, n = 60) = 8.53, p < .01$, No Delay and Delayed Practice conditions respectively. Calculations of effect size revealed the presence of medium sized effects in both conditions, $\Phi = .31$ and $\Phi = .37$, No Delay and Delayed Practice conditions respectively (see Appendix D10 for statistical tables).

Additional Analysis

Output Interference

Using the procedure outlined in Experiment 1a, the possibility that the retrieval-induced forgetting effect found in the No Delay and Delayed Practice conditions was due to output interference was examined. The retrieval-induced forgetting effect for each condition was calculated for the early RP+ and early RP- output groups. Pairwise comparisons confirmed that there were no differences in the magnitude of the retrieval-induced forgetting effects in the early RP+ output group and the early RP- output group in either the No Delay condition ($M = -.13$ vs. $-.13$), $t(28) = 0.06, p = \text{n.s.}$, or

the Delayed Practice condition ($M = -.18$ vs. $-.13$), $t(28) = -.38$, $p = \text{n.s}$ (see Appendix D11 for statistical tables).

Table 5: Likelihood of participants choosing the original item, misinformation, and new erroneous item at forced-choice recognition

Condition	Critical item			Non-critical items
	Original	Misinfo	New error	Mean Error
Delayed Practice	.33	.57	.10	.08 (.11)
No Delay	.50	.50	0	.06 (.06)
Delayed test	.70	.20	.10	.06 (.08)

Note. Misinformation has been presented on RP- items only. For the critical question measuring the misinformation effect, participants had to choose from the correct original item, the misinformation, and a new erroneous item. Proportion of errors on non-critical items (i.e., original item vs. new item vs. new item) is also included as a baseline measure of the proportion of errors made at forced-choice recognition. Standard deviations are enclosed in parentheses.

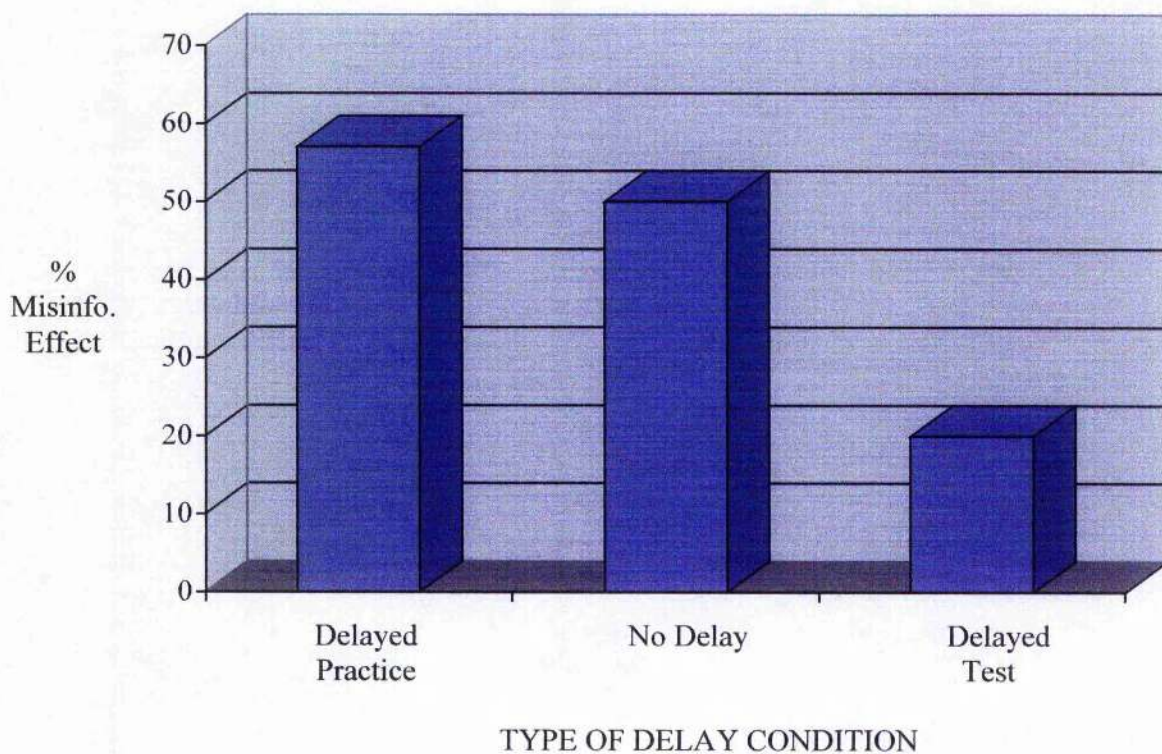
Decreased NRP Performance

1. Cross-category Inhibition

A series of pairwise comparisons were conducted to determine whether cross-category inhibition was present. This analysis is critical due to the absence of a no retrieval-practice control baseline condition in the current series of experiments (due to the main manipulation being delay). It is necessary to demonstrate that the NRP baseline is a relatively pure measure of the recall of unpracticed items from an unpracticed category and that this measure has not been contaminated by the retrieval activity of items in the

retrieval practice set. This was accomplished following the same procedure as outlined previously in Experiment 1a. The mean recall of NRP items that were similar to RP+ items (i.e., NRP-Similar), and of NRP items that were dissimilar (i.e., NRP-Dissimilar), for each condition, was as follows: No Delay ($M = .49$ vs $.38$), $t(29) = 1.83$, $p = \text{n.s}$ and; Delayed Practice ($M = .48$ vs $.49$), $t(29) = -.15$, $p = \text{n.s}$ (see Appendix D12 for statistical tables). A separate set of pairwise comparisons examined the recall of NRP items that were similar to RP- items (i.e., NRP-Similar) and NRP items that were dissimilar (i.e., NRP-Dissimilar): No Delay ($M = .57$ vs $.46$), $t(29) = -.81$, $p = \text{n.s}$ and; Delayed Practice ($M = .44$ vs $.49$), $t(29) = 1.98$, $p = \text{n.s}$ (see Appendix D13 for statistical tables). Therefore, there was no consistent impairment of NRP-Similar items associated with RP+ or RP- items.

Figure 25: Percentage of participants choosing the misinformation option during forced-choice recognition in Experiment 2b



II. Category Dropout

As in Experiment 1a, all of the items can fall into two equal-sized sub-categories: electrical and non-electrical goods, and thus, category dropout may account for the drop in NRP recall in the Delayed Test condition compared to the Delayed Practice condition. Participants in the Delayed Practice condition may benefit from having recently practiced items from these categories leading to increased accessibility of that category (e.g., electrical items). This may increase the likelihood of electrical items in the NRP category being recalled and lead to an increase in NRP items in the Delayed Practice condition. Participants in the Delayed Test condition would not benefit from this increase in accessibility of sub-categories due to the retrieval practice phase occurring before the delay and would suffer from the dropping out of categories. Participants would also be more likely to suffer category dropout for the non-electrical set as these items represent a less coherent group of items (e.g., painting and binoculars have little common features). If, on the other hand, participants were cued with the sub-categories, the recall of NRP items would be restored and may reveal RP-impairment that was otherwise masked by category dropout. However, care was taken to ensure that RP+ sets did not constitute solely these kinds of sub-categories (i.e., practice sets consisted of both electrical and non-electrical goods that were randomised for each participant).

Despite this reasoning, the possibility that the decrease in NRP performance compared to the control baseline was due to category dropout was examined. The proportion of NRP items recalled for each sub-category (i.e., electrical and non-electrical goods) was calculated using pairwise comparisons: Delayed Practice ($M = .51$ vs $.47$), $t(29) = .77$, $p = \text{n.s.}$; No Delay ($M = .48$ vs $.51$), $t(29) = -.45$, $p = \text{n.s.}$; and Delayed Test ($M = .28$ vs $.29$), $t(29) = -.23$, $p = \text{n.s.}$ (see Appendix D14 for statistical

tables). Therefore, there appears to be no evidence of category dropout of electrical or non-electrical goods.

Discussion

The findings that retrieval-induced forgetting is a necessary condition for the production of misinformation effects replicates and extends the main findings of Experiment 1a. In this prior experiment, significant misinformation effects were only found when misinformation was introduced on RP- items, but this in itself was insufficient to account fully for the pattern of results. An even higher proportion of misinformation effects was found when the MisRP- condition was sub-divided into those participants who demonstrated retrieval-induced forgetting (74% of these participants chose the misinformation item) and those who did not (only 17% of these participants did so). Given these prior findings, the current study sought to investigate this boundary condition more thoroughly. The presence of retrieval-induced forgetting during the introduction of misinformation was manipulated by inserting a 24-hour delay into the modified misinformation paradigm. This substantial delay occurred either before recall, before retrieval practice, or not at all.

The results of the current experiment indicate the presence of retrieval-induced forgetting as an essential condition in the production of misinformation effects. When a 24-hour delay was inserted between the retrieval practice phase and free recall, the retrieval-induced forgetting dissipated, suggesting that once sufficient time has elapsed, these related items were no longer subjected to inhibition and were again available for retrieval. Additionally, under these conditions where retrieval-induced forgetting was absent, misinformation also failed to influence responses on the forced-choice recognition test and no significant misinformation effects occurred. This

suggests that previously inhibited RP- items were available in memory, but were not recallable, and able to compete for retrieval with misleading information.

In contrast, when a delay occurred between the presentation phase and retrieval practice, a strong retrieval-induced forgetting effect was elicited. As a result, retrieval-induced forgetting was still present at the introduction, and testing, of the misinformation item. With the RP- item still unavailable in memory it cannot compete with the misleading item, and thus, participants were more likely to choose the misinformation on the forced-choice recognition test.

The results of both Experiments 1 and 2 suggest that retrieval-induced forgetting may be a necessary condition in the production of the misinformation effect. Further, these studies suggest that the presence of retrieval-induced forgetting, as well as the retrieval inhibition of the RP- item, play a strong role in the reporting of the misleading item. Thus, it would appear that when an item is subjected to retrieval inhibition it is relatively easy to introduce information about that item. However, the success of introducing misleading information appears to be dependent on retrieval-induced forgetting currently being present so that the RP- item is subjected to retrieval inhibition. If retrieval-induced forgetting is absent, then RP- items are unlikely to be subjected to retrieval inhibition, and so significant misinformation effects are not found.

The results of Experiments 1 and 2 also have a more general application to current theories of memory updating. As recent research suggests that retrieval inhibition may play an adaptive role in memory updating (e.g., R.A. Bjork, 1989; M.D. MacLeod et al., 2003), the finding that information can be introduced on items that are subjected to retrieval inhibition, and then reported in place of that original material, is an important advancement in memory research. Thus, the application of retrieval

inhibition to the misinformation effect need not be seen as having exclusively negative consequences for memory. In fact, the prior inhibition of out-of-date or unwanted information may prevent it from interfering with the encoding of newer information, and so may ultimately be beneficial for the updating of memory.

These findings may also increase our understanding of the possible negative consequences of misleading post-event information on eyewitness memory. Not only do these findings support research that has previously demonstrated that repeated questioning can elicit retrieval-induced forgetting (M.D. MacLeod, 2002; Shaw et al., 1995), but also that this repeated questioning can leave individuals vulnerable to misinformation. Thus, this research may have some application to situations concerning the validity of testimony from witnesses, suggesting that the questioning of eyewitnesses may lead to omissions of some details, and an increased susceptibility to post-event misleading information. If this is indeed the case, then this is a double blow for questioning techniques, such as the standard police and cognitive interview, that are based on repeated questioning (e.g., Fisher & Geiselman, 1988).

Both Experiments 1 and 2 have examined the role of retrieval-induced forgetting in the promotion of misinformation effects. The impaired recall of RP- items in both of these studies have been assumed to be the result of the retrieval inhibition of related information competing with the RP+ items for retrieval. However, the modified misinformation paradigm employed in both of these experiments was not designed specifically to explore the activation status of the underlying memorial representations of the RP- items. Specifically, the paradigm does not differentiate between retrieval inhibition that may be the result of inhibitory or non-inhibitory mechanisms. Thus, the term 'retrieval inhibition' has been used in a fairly weak

descriptive sense to indicate that the effect is an empirical effect that is the opposite of facilitation (e.g., R.A. Bjork, 1989), rather in a mechanistic sense.

However, in order to look more closely at the underlying mechanisms of retrieval-induced forgetting, and to specifically examine whether inhibitory processes are an underlying mechanism to the misinformation effect, a more specialised paradigm is required. M.C. Anderson and Spellman (1995) designed a retrieval method, the independent probe method, which can measure the presence of 'true' inhibitory processes (i.e., inhibitory mechanisms). Therefore, Experiment 3 will adapt this independent probe method for use with the type of materials that were used in Experiments 1 and 2 in order to investigate whether RP- items are truly inhibited in retrieval-induced forgetting or not.

CHAPTER 7

EXPERIMENT 3: INHIBITORY PROCESSES IN RETRIEVAL-INDUCED
FORGETTING

As Experiments 1 and 2 have demonstrated a role for retrieval-induced forgetting in the production of misinformation effects, Experiments 3 – 5 will examine whether the mechanism underlying the misinformation effect is inhibitory in nature. But it must first be established whether inhibitory or non-inhibitory processes underlie retrieval-induced forgetting. As such, the current study will examine the underlying processes of retrieval-induced forgetting by adapting the independent probe method designed by M.C. Anderson and Spellman (1995) for use with materials similar to those use in Experiments 1 and 2.

The independent probe method is a cued-recall method that employs retrieval cues during the final memory test that differ to those that were used during the retrieval practice phase. The independent probe method can differentiate the actions of inhibitory from non-inhibitory mechanisms through the use of retrieval cues at final recall that differ to the ones that where used during retrieval practice. Thus, inhibitory theories predict a different pattern of results using novel retrieval cues to that of non-inhibitory theories. This difference in predictions is primarily due to the way that non-inhibitory theories explain retrieval inhibition effects. Non-inhibitory theories assume that strengthening the association between a cue and an item (i.e., RP+ items) during retrieval practice results in a corresponding weakening in the association between that retrieval practice cue and the RP- items. Thus, non-inhibitory theories predict that the main site of interference is at the level of the retrieval routes between cue and memory. As a result, if non-retrieval practice cues are used during final

recall then interference will be overcome and retrieval-induced forgetting will not be found. Such forgetting is typically referred to as being cue-dependent (M.C. Anderson & Spellman, 1995; Tulving, 1974).

In contrast, inhibitory theories assume that retrieval-induced forgetting is the result of inhibitory processes directly acting on the memorial representations of competing items (i.e., RP- items). As a result, the memorial representation of RP-items is suppressed. In addition, as the suppression of RP- items is not due to their association with the retrieval practice cue (unlike non-inhibitory theories), these items will remain inhibited even when novel retrieval cues (i.e., cues that differ to those used during retrieval practice) are employed at final recall. Thus, inhibitory theories assume that retrieval-induced forgetting is an example of cue-independent forgetting (M.C. Anderson & Green, 2001; M.C. Anderson et al., 2000b; M.C. Anderson & Spellman, 1995; Levy & Anderson, 2002).

Adapting the independent probe method for use with materials that would be appropriate for the subsequent exploration of inhibitory processes in producing the misinformation effect is, however, problematic. This is primarily due to the independent probe method having only been used with well-defined pre-experimental categories in the past, such as semantic categories (e.g., FRUIT; M.C. Anderson & Spellman, 1995), or geometric shapes (e.g., triangles, crosses; Ciranni & Shimamura, 1999). However, the stimuli typically used to examine misinformation effects do not fall into such well-defined semantic categories. For example, the materials used in Experiment 1a formed only episodic categories, rather than semantic categories, and can only be loosely defined as 'items found in a house'. Despite this problem, the independent probe method should be able to be adapted for use with episodic memories by changing the retrieval practice cues from semantic category cues that are

typically used in the retrieval practice paradigm to episodic cues. For example, if the target items are divided into 'Thompson's House' and 'Williams' House' then using these labels as retrieval practice cues should be sufficient.

Hypotheses

The prior use of the independent probe method for investigating the underlying mechanisms of retrieval-induced forgetting allows several predictions to be made. If the retrieval-induced forgetting effect typically found for complex episodes is an inhibitory one, then the retrieval-induced forgetting effect should still be found even when novel cues are used to prompt recall. Specifically, if the memorial representations of the RP- items are truly inhibited, then recall of these items should still be impaired, even when the retrieval cues used to aid the recall of the RP- items differs from the retrieval practice cue used to strengthen the RP+ items. However, if the retrieval-induced forgetting effect is in fact a non-inhibitory one, then the recall performance of RP- items can be expected to be similar to the NRP category (i.e., retrieval-induced forgetting will be absent).

Method

Participants and Design

Fifty undergraduate and postgraduate students and members of the public (32 men and 18 women) participated on a voluntary basis in this study. Item type was manipulated within subjects and had three levels: (1) RP+ items, which were practiced items from the practiced set; (2) RP- items, which were unpracticed items from the same practiced set, and (3) NRP items, which were items from a separate

and unpracticed set. Treatment was manipulated between subjects and had two levels: (1) retrieval practiced condition, where participants practiced the RP+ items three times each, and (2) no relevant retrieval practice, which acted as a control measure. Both conditions each contained twenty-five participants.

Materials

Study Materials

In the study phase participants were required to read two narratives containing information about two separate burglaries. The first part of each narrative contained scene-setting information about when and where the incidents occurred. One narrative concerned the theft of ten items from the Thompson's house while the family were on vacation. The second theft concerned the theft of ten items from the Williams' house while the family had been visiting relatives. Each item was presented embedded within a sentence describing where in the house the item had been stolen from, e.g. 'The mobile phone had been in the hallway. It had belonged to Mr. Thompson who needed it for his job as a doctor'. Participants were informed that the underlined words represented the stolen items. Each item was presented on a separate page of a booklet. Items for each burglary were presented in block format (i.e., the narrative and all items from the Thompson's house was followed by the narrative and all the items from the Williams' house, or vice versa), and their presentation was randomised within each block. The information sets for each house could be divided into two subgroups, each containing five items, in order to create a practiced set (i.e., RP+ group), and an unpracticed set (i.e., RP- group) for each house.

Items were chosen that had only weak semantic associations to other items², as established in previous pilot work (see Appendix E1), and whose first two letters were different to every other target item (Thompson's house: hockey stick, mobile phone, PlayStation, necklace, guitar, armchair, painting, microwave, lamp, vase; Williams' house: perfume, rucksack, hammer, fountain pen, telescope, clock, stereo, leather jacket, printer, calculator). See Appendix E2 for both narratives.

Retrieval Practice Questions

As there were ten items in each house, items from one house could form the practiced category (i.e., RP+ and RP- sub-sets), and those items from the other house could form the unpracticed category (i.e., NRP group). Participants in the experimental condition received three sets of questions about half of the items from one of the houses. Therefore, these participants received fifteen retrieval cues in total related to the same five items (see Appendix E3 for a full list of retrieval practice questions). Each question increased in difficulty as participants progressed through the booklet; previous work has determined that increasing the difficulty of the retrieval task leads to maximised practice effects (Landauer & Bjork, 1978). The difficulty of each set of retrieval practice questions had been determined in earlier pilot work (cf. M.D. MacLeod, 2002). An independent group of participants ($n = 15$), who had not previously read either of the narratives, had been presented with questions from either Set 1 ($M = .97$), Set 2 ($M = .62$), or Set 3 ($M = .33$). Questions from Set 1 were determined to be significantly easier than questions from Set 2, $t(8) = 19.30, p < .01$, and Set 3, $t(8) = 10.98, p < .01$. Similarly, questions from Set 2 were found to be

² In a pilot study, 10 participants were presented with a list of 83 items that can be found in a house and where asked to group them by similarity, and to state why they were similar. No participant divided the items into "electrical" and "non-electrical" items, or decided that all 83 items were similar because they could be found in a house, or were considered "stealable".

significantly easier than questions from Set 3, $t(8) = 4.99$, $p < .01$, see Appendix E4 for statistical tables. In addition, the time of the distracter tasks increased in length between each of the retrieval practice sets in order to produce an expanding schedule that maximised task difficulty (M.C. Anderson et al., 1994; Shaw et al., 1995). Participants in the control condition did not receive a retrieval practice task about any of the stolen items. Rather, they received the same non-relevant retrieval practice task (cf. Macrae & MacLeod, 1999) that was used in the control condition of Experiment 1a (e.g., the capital city of Cuba is Ha_____), see Appendix A4.

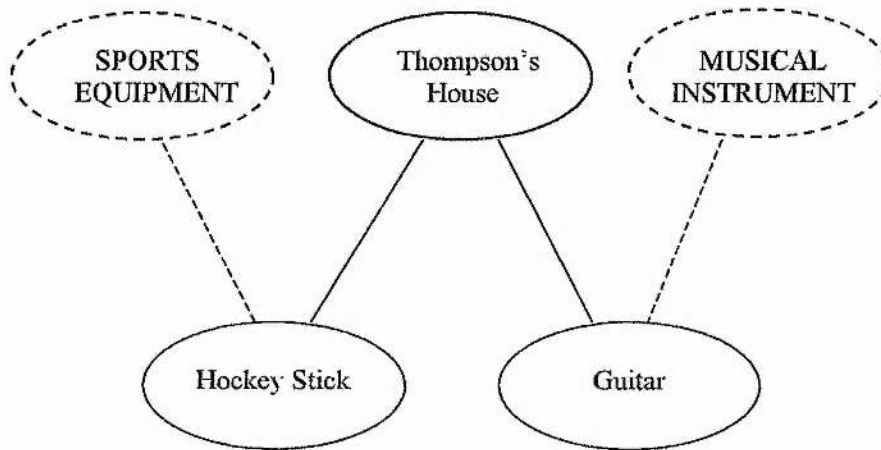
Recall Booklets

A cued-recall task based on M.C. Anderson and Spellman's (1995) independent probe technique was employed as a manipulation check. The independent probe technique uses novel cues that have not previously been used to prompt recall in the experiment (see Figure 26). The appropriateness of the cues was examined in previous pilot work where participants had to match items to category names³ (see Appendix E5). This determined whether the category name was appropriate for its members. In addition, each cue was followed by a two-letter stem to prompt recall. The stem completion task was contained in a four page booklet, where five items were cued on each page,

³ Based on previous pilot work examining similarity of items (for study materials), category names were constructed for the same list of 83 items. Participants were asked to match these items to a category label, and to indicate which items were the best and worst examples of the category label. For items that were deemed a poor example of the category label (but didn't fit under any of the other labels), participants were prompted to generate a better category label for that item.

and recall never commenced with the cueing of previously practiced items to prevent the early recall of practiced items interfering with the output of later items (see Appendix E6 for this cued-recall test).

Figure 26: The independent probe method



Note. "Thompson's House" is the experimental (episodic) cue used in the study and retrieval practice phases. Novel (semantic) cues (e.g., "SPORTS EQUIPMENT") were employed in the recall phase. Participants were cued to recall each item using a novel cue followed by the items first two letters (e.g., SPORTS EQUIPMENT- Ho_____).

Procedure

The experiment proceeded in a similar manner to that of Shaw et al. (1995) and M.D. MacLeod (2002) with each participant completing a study phase, a practice phase interleaved with distracter tasks, and a final recall task. Participants arrived at the laboratory in groups of up to five, were greeted by a female experimenter, and alternatively assigned to either the experimental condition or the control condition. Participants were informed that they would be taking part in a memory experiment

and were instructed to read two narratives about two separate burglaries. The order of the presentation of the two narratives had been alternated throughout. Participants had 45 seconds to read the first part of the narrative containing the scene setting information and 5 seconds to read each sentence that contained the stolen item.

On completion of the study phase, participants in the experimental condition were presented with a retrieval practice task that contained three sets of questions that required participants to retrieve half of the items from one of the houses from memory (i.e., participants were cued to recall five items a total of three times each). These practiced tasks were also interleaved with distracter tasks that increased in length after each practiced set. That is, a three-minute distracter task followed the first practice set, a four-minute distracter task followed the second practice set, and a five-minute distracter task followed the final practice set. These distracter tasks took the form of anagrams of fruit, vegetables, and academic subjects, and no participant completed the tasks in the allocated time (see Appendix E7). Participants in the control condition followed this same procedure, except that they completed the non-relevant retrieval practice task.

Following completion of the final distracter task, participants were asked to try to recall the names of the stolen items from the two burglaries using a cued-recall stem completion task that was contained in a four-page booklet. Each item was cued with a novel cue that was unique to that item. There were five cued stems on each page and participants had fifty seconds to complete each page of the recall booklet before they were prompted to turn to the next page. This recall task measured whether retrieval-induced forgetting had occurred. On completion of this task, participants were thanked, debriefed and dismissed.

Results

Retrieval Practice and Mean Recall Performance

The retrieval practice success rate for the practice condition was 85% ($SD = .08$). Table 6 displays the mean recall for each item type for the practice and the control conditions. Mean recall of the practiced (i.e., RP+) items was .90, while recall performance of the unpracticed set (i.e., NRP items) was .76. The difference between the RP+ items and NRP items (+.14) demonstrates the facilitatory effects of prior retrieval on memory performance. In addition, recall performance of the unpracticed items from the practiced set (i.e., RP- items) was .63 in comparison with the recall of the unpracticed set (i.e., NRP items, .76). This difference in recall performance (-.13) demonstrates the effects of retrieval-induced forgetting, whereby the prior retrieval of other items from memory leads to impaired recall of competing items, and is comparable to the level of impairment found in previous studies (e.g., M.C. Anderson et al., 1994; M.C. Anderson & Spellman, 1995; M.D. MacLeod, 2002; M.D. MacLeod & Macrae, 2001; Macrae & MacLeod, 1999).

Transformation of Data

The recall scores (proportion correct) within each condition were transformed using arcsin transformation in order to establish homogeneity of variance (see Snedecor & Cochran, 1980, pp. 290-291).

Retrieval-induced Forgetting

A single factor (item type: RP+, or RP-, or NRP) within-subjects ANOVA demonstrated a significant main effect of item type for the retrieval practice condition, $F(2, 48) = 22.70$, $p < .01$, $MSe = .08$. Cohen's f was calculated as an unbiased

measure of effect size (Cohen, 1988), and indicates the presence of a large effect (Cohen's $f = 0.56$). Using Holm's sequential Bonferroni approach, a series of post-hoc pairwise comparisons revealed both facilitatory effects (i.e., $RP+ > NRP$, $t(24) = 4.37$, $p < .01$), and retrieval-induced forgetting effects (i.e., $RP- < NRP$, $t(24) = -2.09$, $p < .05$), see Appendix F1 for statistical tables.

Table 6: Mean recall performance for retrieval practice and control (non-relevant practice) conditions

Condition	Item Type			Retrieval-induced Forgetting
	RP+	RP-	NRP	(RP-) - NRP
Practice	.90 (.10)	.63 (.23)	.76 (.13)	-.13

Note. RP+ = practiced items from the practiced category. RP- = unpracticed items from the practiced category. NRP = unpracticed items from the unpracticed category. Recall of items in the control condition = .78 (SD = .09). Standard deviations are enclosed in parentheses.

Finally, to check that the retrieval-induced forgetting effect was not due to increased recall of the NRP items, rather than a decrease in the RP- items, the recall performance of the NRP items was compared with performance in the Control condition. No differences were found between these two groups, $t(48) = .27$, $p = n.s.$ suggesting that the retrieval-induced forgetting effect is due to a genuine decrease in the recall of RP- items (see Appendix F2 for statistical table).

Output Interference

As the final recall task was a cued-recall task that commenced with unpracticed items (i.e., NRP and RP-), the RP+ items were not recalled first, and therefore could not have blocked retrieval of the unpracticed items, output interference is unlikely to have contributed to the observed recall performance.

Discussion

According to M.C. Anderson and Spellman's (1995), the independent probe technique provides a method for determining whether retrieval-induced forgetting is primarily the result of inhibitory or non-inhibitory processes. Finding retrieval-induced forgetting using the independent probe method is typically considered the strongest evidence for inhibitory processes acting in memory. Thus, the current finding that retrieval-induced forgetting is still evident in the independent probe method suggests that inhibitory processes do, in fact, underlie the effect. Recall of RP- items was impaired even though these items did not share the same retrieval cue that was used to strengthen the RP+ items during the retrieval practice phase. This suggests that the memorial representations of RP- items were inhibited rather than retrieval-induced forgetting being due to interference occurring between the retrieval practice cue and the RP- item (which would have indicated non-inhibitory processes).

More generally, the current finding suggests that inhibitory processes may play a role in setting aside unwanted or out-of-date information during the updating of memory. Thus, inhibitory processes may allow for the goal-directed forgetting of unwanted information in order to prevent it from interfering with the retrieval of desired memories.

It should also be noted that retrieval-induced forgetting was found using the independent probe method even though the materials used in this study were quite different to those used by M.C. Anderson and Spellman (1995). Target items and their presentation were very different, and for example, while M.C. Anderson and Spellman employed categories of items that formed well-defined semantically related groups (e.g., FRUIT, RED), the current study only used two categories (i.e., Thompson's House, Williams' House) of loosely related items, that only gained collective meaning within the context of the experiment (e.g., "stealable things" or "household items"). In addition, the use of questions as a retrieval practice task in the current study was quite different to that used by M.C. Anderson and Spellman, who used a cue-plus-stem task. However, these differences underline both the robustness of the retrieval-induced forgetting effect and the role of inhibitory processes in memory.

The inhibition of the memorial representation also has some implications for theories of memory, as well as for various real-world memory situations. Many theories of memory are primarily based on the assumption that forgetting is a cue-dependent phenomenon. For example, for example Mensink and Raajimakers (1988) SAM model assumes that forgetting occurs due to interference between the retrieval cue and the trace. As a result, if a novel cue is employed to test memory the interference is lifted. Similarly, Tulving's encoding specificity principle (Tulving & Thompson, 1973) is based on the assumption that forgetting is primarily cue-dependent in nature. According to this view of memory, employing cues used at encoding should alleviate interference and increase the probability of a memory being retrieved. The idea of encoding specificity and cue-dependent forgetting has also formed the basis of the cognitive interview for questioning witnesses (e.g., Fisher &

Geiselman, 1988). The cognitive interview attempts to gain a more complete account of an event through the use of multiple retrieval cues. Thus, if the retrieval of a memory is blocked due to interference, then employing different retrieval cues, or employing multiple retrieval cues, should aid in its retrieval. However, the increasing evidence for cue-independent forgetting suggests that theories of memory retrieval, and questioning techniques such as the cognitive interview, need to consider the possibility that memorial representations can themselves be inhibited, and that this retrieval inhibition is not easily resolved through employing multiple novel retrieval cues.

While the current experiment examined cue-independent forgetting – perhaps the strongest evidence for inhibitory processes in forgetting – another intriguing finding by M.C. Anderson and Spellman (1995) is also consistent with an inhibitory account of retrieval-induced forgetting, that of cross-category and second-order inhibition. M.C. Anderson and Spellman found that when an NRP item was semantically related to item from the practiced category recall performance of these *NRP-Similar* items was also impaired. Thus, in order to investigate further the parameters of the inhibitory account of retrieval-induced forgetting, Experiment 4 will attempt to replicate cross-category and second-order inhibitory effects using similar materials to those employed in Experiment 3.

CHAPTER 8

EXPERIMENT 4: CROSS-CATEGORY AND SECOND-ORDER INHIBITION IN
RETRIEVAL-INDUCED FORGETTING

In addition to cue-independent forgetting with the independent probe method, M.C. Anderson and Spellman (1995) also found one unexpected result, an effect they named second-order inhibition. Second-order inhibition is a specific form of cross-category inhibition, and occurs under condition where NRP items are similar to RP-items (M.C. Anderson & Spellman, 1995, Experiment 2 and 4). NRP items that are semantically related to items from the practiced category tend to be referred to as *NRP-Similar* items (M.C. Anderson & Spellman, 1995). Typically, NRP item that are semantically similar to an inhibited RP- item are also inhibited, despite not being drawn from the same category as the RP+ item, and as a result, are unlikely to compete with the RP+ item for retrieval. While inhibitory theories neither predict nor fully account for second-order effects, inhibitory processes do provide a more parsimonious account than non-inhibitory theories. As M.C. Anderson and Spellman have previously demonstrated that both the prior practice of items (rather than merely presenting items), as well as NRP items sharing a degree of similarity with the RP-items, are both essential conditions in the production of second-order inhibition effects (M.C. Anderson & Spellman, 1995, Experiment 3a and 3b), inhibition provides a more complete and direct account of cross-category inhibition than do non-inhibitory theories. Thus, in the case of second-order effects, any item that shares a degree of similarity or association with an inhibited RP- item may also be susceptible to inhibition, even if those items share no features directly with the RP+ items. It is almost as if the inhibition 'leaks' from the inhibited RP- items to any item that is

related to it. In contrast, non-inhibitory theories are unable to account for second-order inhibition as NRP-Similar items are not drawn from the same category as the practiced items. As a result, the RP+ items are studied, practiced, and tested under different retrieval cues to the NRP-Similar items.

Similarly, the more simplistic cross-category inhibition occurs when an NRP item is semantically similar to the RP+ items, and so competes directly for retrieval with these items. As a result of this competition, the semantically related NRP items are inhibited (M.C. Anderson & Spellman, 1995, Experiment 1). NRP items that are similar to the practiced items, are in effect, merely acting like a second group of RP-items. This is perhaps quite surprising, given that facilitatory priming effects (e.g., Neely, 1976, 1977), and spreading activation models (J.R. Anderson, 1983; Freedman & Loftus, 1971; E.F. Loftus, 1973; G.R. Loftus & Loftus, 1974; Roediger & McDermott, 1995), would predict facilitated recall for any item that was semantically similar to practiced items.

In contrast to these two types of NRP-Similar items, items from the unpracticed category that are semantically dissimilar to items from the practiced category are not inhibited. As NRP-Dissimilar items are not drawn from the same category as the practiced items they do not compete directly with the RP+ items for retrieval. In addition, as they are also unrelated to the inhibited RP- items recall of NRP-Dissimilar items is not impaired through inhibition spreading from the items.

M.C. Anderson and Spellman's (1995) finding that recall performance for NRP-Similar items is impaired may suggest that inhibitory processes can control the effects of spreading activation from the practiced items (or vice versa). This interpretation is given credence when all the unpracticed items are considered. RP-, NRP-Similar and NRP-Dissimilar items have all been treated in the same manner

during the experimental episode, with participants only viewing them during the initial study phase. Yet, recall performance of the NRP-Dissimilar items is the only item type that remains unaffected by the prior retrieval of the RP+ items. The likeliest explanation for this scenario is that recall performance is dependent on each class of item's relation to the strengthened RP+ item. As the activation of an item is thought to result in the spreading of activation to the memorial representations of other related items (e.g., Neely, 1977; Roediger & McDermott, 1995) inhibitory processes may be brought to bear on related items in order to prevent them from being activated (i.e., RP- and NRP-Similar items). If related items were not inhibited both RP- and NRP-Similar items are likely to become increasingly competitive and interfere with the retrieval of the RP+ items. In contrast, as the NRP-Dissimilar items are semantically unrelated to the practiced items they are unlikely to be the recipient of any kind of spreading semantic activation, or semantic (or associative) priming effects. As a result, NRP-Dissimilar items will neither compete for retrieval with the RP+ items, nor be subjected to inhibition.

In order to investigate these second-order and cross-category effects, related categories that span the two incidents will be introduced in the current study, allowing the role of inhibitory processes in the production of these effects to be examined (i.e., NRP items similar to RP+ items or RP- items). Specifically, if there are sub-categories of related items that span both incidents, can the practice status of some of those items influence the recall of semantically similar items in the unpracticed incident? If the RP+ items are similar to some items from the unpracticed category, will these unpracticed items also benefit from the prior retrieval of related information, or will they be impaired due to these items creating interference at retrieval (i.e., cross-category impairment)? Also, if some items from the unpracticed

category are similar to the RP- items from the practiced category, will these similar NRP items also be impaired, or will their recall be unaffected because their similarity lies with the competing information, not with the practiced items?

In order to accomplish this, the target items used in Experiment 3 need to be modified to include sub-categories of related items that span the two incidents. This will require the NRP category to be sub-divided into two distinct item types: NRP-Similar items and NRP-Dissimilar items. Additionally, the category needs to be further divided into those items that are semantically similar to practiced items and those items that are semantically similar to the unpracticed RP- items.

Hypotheses

The independent probe method will again be used to measure whether inhibitory processes are responsible for both retrieval-induced forgetting, and cross-category and second-order effects. As a result, the current experiment will attempt to replicate the cue-independent forgetting of the RP- items that was demonstrated in Experiment 3.

In addition to the impaired recall of RP- items, if inhibitory processes are triggered by the selective retrieval of the RP+ items, then the recall performance of the NRP-Similar items is also expected to be impaired. This decrease in NRP-Similar performance compared to NRP-Dissimilar items should occur irrespective of whether the NRP-Similar items share a related sub-category with the RP+ items or the RP- items. Under conditions where items from the unpracticed category are related to RP+ items, this semantic similarity should cause competition for retrieval between the RP+ items and the NRP-Similar items. These unpracticed but similar items should, therefore, be inhibited so that the RP+ items can be successfully recalled.

In addition, items from the unpracticed category can also be semantically similar to RP- items. While these NRP-Similar items do not compete directly with the RP+ items for retrieval, they do share features with the competing RP- items and so inhibition is expected to spread to the NRP-Similar items. The remaining NRP items, which share no related features with the practiced category, are not expected to be affected by the prior retrieval of the RP+ items. As the NRP-Dissimilar items are unrelated to the practiced category they are not expected to compete for retrieval with the RP+ items and can therefore act as the baseline measure of recall.

Method

Participants and Design

Ninety students and members of the public (52 men and 38 women) participated on a voluntary basis in this study. Item type was manipulated within subjects and comprised four levels: (1) RP+ items, which were practiced items from the practiced set; (2) RP- items, which were unpracticed items from the same practiced set; (3) NRP-Similar items, which were items from the unpracticed set that were semantically similar to items from the practiced set (either RP+ or RP- items), and (4) NRP-Dissimilar items, which were items from the unpracticed set that were semantically dissimilar to all items from the practiced set.

The semantic similarity of NRP-Similar items to items from the practiced category was manipulated between subjects and had three levels: (1) NRP-Similar items, semantically related to a sub-set of RP+ items (the *NRP-Similar to RP+* condition); (2) NRP-Similar items, semantically related to a sub-set of RP- items (the *NRP-Similar to RP-* condition); and (3) no relevant retrieval practice (*Control*

condition), which acted as a control measure. Each condition contained thirty participants.

Materials

Study Materials: Narratives

In the study phase participants were required to read two narratives containing information about two separate burglaries. The first part of each narrative contained scene-setting information about when and where the incidents occurred. One narrative concerned the theft of twelve items from the Thompson's house while the family were on vacation. The second theft concerned the theft of twelve items from the Williams' house while the family had been visiting relatives. Each item was presented embedded within a sentence describing where in the house the item had been stolen from, e.g. '*The mobile phone had been in the hallway. It had belonged to Mr. Thompson who needed it for his job as a doctor*'. Participants were informed that the underlined words represented the stolen items. Each item was presented on a separate page of a booklet. Items for each burglary were presented in block format (i.e., the narrative and all items from the Thompson's house were followed by the narrative and all the items from the William's house, or vice versa), and their presentation was randomised within each block (see Appendix G1 for both narratives in their entirety).

One house formed the practiced category and the remaining house formed the unpracticed category. The stolen items for each house could be divided into four subgroups: practiced items from the practiced category (i.e., RP+); unpracticed items from the practiced category (i.e., RP- items); items from the unpracticed category that were semantically similar to items from the practiced category (i.e., NRP-Similar), or;

items from the unpracticed category that were semantically dissimilar to items from the practiced category (i.e., NRP-Dissimilar). Six items from the practiced category formed the RP+ sub-set and the remaining six items formed the RP- sub-set. Four items from the unpracticed category formed the NRP-Similar sub-set and the remaining eight items formed the NRP-Dissimilar sub-set.

Study Materials: Semantically Dissimilar Target Items

Eight items from each house formed the NRP-Dissimilar set, and these items were chosen for their weak semantic associations to all other items. This semantic dissimilarity was determined in previous pilot work⁴ (see Appendix E1). In addition, no item commenced with the same first two letters (Thompson's house: *hockey stick, mobile phone, PlayStation, guitar, painting, microwave, lamp, vase*; Williams' house: *perfume, rucksack, hammer, fountain pen, camera, telescope, clock, stereo*).

Study Materials: Semantically Similar Target Items

The remaining four items in each house formed two sub-categories of implicitly related items, as determined by previous pilot work⁵ (see Appendix E1). Specifically, these implicit sub-categories contained four related items that spanned both narratives, (i.e., for the first sub-category, two related items were in the Williams narrative, and the remaining two items were in the Thompson narrative), and the same format was used for the second sub-category of related items. However, due to issues with item randomisation for the retrieval practice questions, there were actually three

⁴ Information concerning the semantic dissimilarity of items was taken from the pilot study described in Experiment 3.

⁵ This information was also taken from the pilot study of Experiment 3. Attempts were made to ensure that items within these implicit categories did not share too high or too low a degree of similarity (see M.C. Anderson et al.'s 2000b two-factor theory on the effects of similarity on retrieval-induced forgetting for further details on this problem).

sets of implicit sub-categories (clothing: *leather jacket, trainers, sweater, jeans*; jewellery: *necklace, earrings, cufflinks, wedding ring*; and furniture: *bookcase, armchair, desk, table*), but participants only read about two of them. This was to prevent all the RP+ items in the NRP-Similar to RP+ condition being from the implicit sub-categories (i.e., out of the 6 RP+ items, all 6 would be from the implicit sub-categories), and all the RP- items from the NRP-Similar to RP- condition being from the implicit categories, with no opportunity for randomisation. Therefore, each pair of implicit sub-categories that was shared across the narratives was randomised and counterbalanced throughout.

Retrieval Practice Questions

Participants in the experimental conditions received three sets of questions about half of the items from one of the houses (i.e., six RP+ items). Therefore, these participants received eighteen retrieval cues in total that related to the same six items (see Appendix G2 for the complete set of retrieval practice questions). Each retrieval practice task increased in difficulty in order to maximise practice effects (Landauer & Bjork, 1978) and question difficulty was established in previous pilot work, as described in Experiment 3 (see Appendix E4 for that statistical analysis concerning question set difficulty). In addition, the time of the distracter tasks increased in length between each of the retrieval practice sets in order to produce an expanding schedule that maximised task difficulty (M.C. Anderson et al., 1994; Shaw et al., 1995).

In the NRP-Similar to RP+ condition, half of the items from the implicit sub-categories formed part of the RP+ set in order for the corresponding implicit sub-category members in the NRP set to be related to RP+ items (i.e., NRP-Similar items, see Figure 27). In the NRP-Similar to RP- condition, half of the items from the

implicit sub-categories formed part of the RP- set in order for the remaining implicit sub-category members in the NRP set to be related to these RP- items (i.e., NRP-Similar to RP- items, see Figure 28). Participants in the Control condition did not receive a retrieval practice task about any of the stolen items. Rather, they received the same non-relevant retrieval practice task that was used in the Control condition of Experiment 1a (e.g., the capital city of Cuba is Ha_____), see Appendix A4.

Figure 27: Organisation of implicit categories in the NRP-Similar to RP+ condition

Practiced Set		Unpracticed Set
wedding ring	JEWELLERY	<i>necklace</i>
cuff links		<i>earrings</i>
leather jacket	CLOTHING	<i>jeans</i>
trainers		<i>sweater</i>
clock		<i>painting</i>
stereo		lamp
telescope		guitar
camera		PlayStation
fountain pen		mobile phone
hammer		hockey stick
rucksack		microwave
perfume		vase

Note. An example of how implicit sub-categories span the practiced and unpracticed sets in the NRP-Similar to RP+ condition where items from the unpracticed set are semantically related to RP+ items. Practiced items are in bold type. NRP-Similar items are in italics, and are items from the unpracticed set that are semantically related to items from the practiced set. The remaining non-italicised items in the unpracticed set are NRP-Dissimilar items, which are items from the unpracticed set that are semantically dissimilar to items from the practiced set.

Figure 28: Organisation of implicit categories in the NRP-Similar to RP- condition

Practiced Set		Unpracticed Set	
telescope		mobile phone	
camera		lamp	
perfume		hockey stick	
stereo		microwave	
fountain pen		vase	
hammer		painting	
clock		guitar	
rucksack		PlayStation	
leather jacket	CLOTHING	<i>jeans</i>	
trainers		<i>sweater</i>	
wedding ring		<i>necklace</i>	
cuff links	JEWELLERY	<i>earrings</i>	

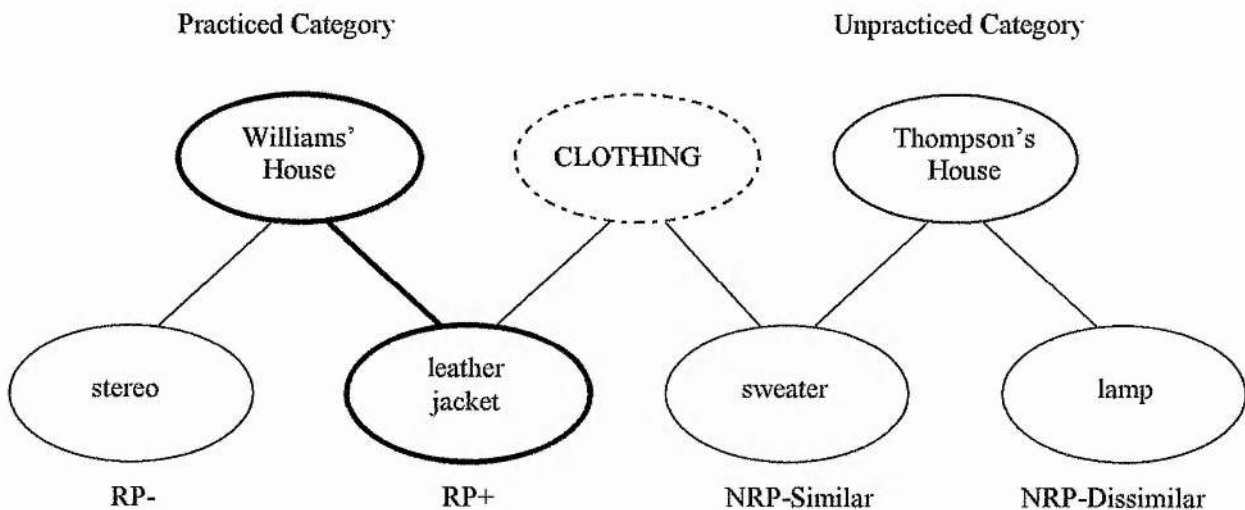
Note. An example of how implicit sub-categories span the practiced and unpracticed sets in the NRP-Similar to RP- condition where items from the unpracticed set are semantically related to RP- items. Practiced items are in bold type. NRP-Similar items are in italics, and are items from the unpracticed set that are semantically related to items from the practiced set. The remaining non-italicised items in the unpracticed set are NRP-Dissimilar items, which are items from the unpracticed set that are semantically dissimilar to items from the practiced set.

Recall Booklets

The independent probed task that was used in Experiment 4 was adapted for use with implicit sub-categories from the task employed in Experiment 3, and the appropriateness of these novel cues was established in pilot work (see Appendix E5 for further details of this pilot study). This cue-plus-stem task (e.g., MUSICAL INSTRUMENT-Gu_____) was spread over an eight-page booklet, where three items were cued on each page (see Appendix G3 for this cued-recall test). This was to ensure that items belonging to the same implicit sub-category never appeared on the same page, or on the page afterwards, in order to prevent participants using previously recalled items to prompt the recall of other items. In addition, recall never

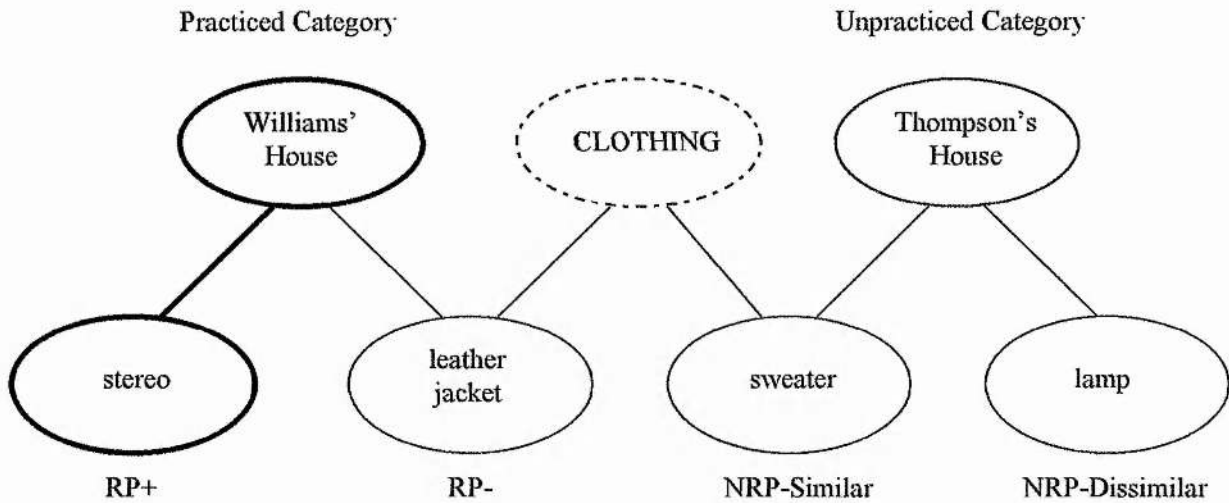
commenced with the cueing of previously practiced items (i.e., RP+ items were never cued on the first page of the recall booklet) to prevent the early recall of practiced items blocking the recall of weaker items (i.e., RP-, NRP-Similar and NRP-Dissimilar items). See Figure 29 for a diagram of the independent probe method used in the NRP-Similar to RP+ condition, and Figure 30 for the NRP-Similar to RP- condition.

Figure 29: Independent probe method in the NRP-Similar to RP+ condition



Experimental and novel cues used at final recall in experiment 4. "Thompson's House" is the experimental (episodic) cue used in the study and retrieval practice phases. Novel (semantic) cues (e.g., "SPORTS EQUIPMENT") were employed in the recall phase. Participants were cued to recall each item using a novel cue followed by the items first two letters (e.g., SPORTS EQUIPMENT-Ho_____).

Figure 30: Independent probe method in the NRP-Similar to RP- condition



Note. Experimental and novel cues used at final recall in Experiment 4. "Thompson's House" is the experimental (episodic) cue used in the study and retrieval practice phases. Novel (semantic) cues (e.g., "SPORTS EQUIPMENT") were employed in the recall phase. Participants were cued to recall each item using a novel cue followed by the items first two letters (e.g., SPORTS EQUIPMENT- Ho_____).

Procedure

Participants arrived at the laboratory individually or in groups of up to six and randomly assigned to one of the testing conditions. Participants were informed that they were to take part in a memory task and were instructed to read two narratives about two separate burglaries. The order of presentation of the two narratives had been counterbalanced throughout. Participants had 45 seconds to read the first part of the narrative containing the scene-setting information and 5 seconds to read each sentence that contained the stolen item.

On completion of the study phase, participants in the experimental conditions were presented with a retrieval practice task that contained three sets of questions that

required participants to retrieve half of the items from one of the houses from memory (i.e., participants were cued to recall six items a total of three times each). These practiced tasks were also interleaved with distracter tasks that increased in length after each practiced set. That is, a three-minute distracter task followed the first practice set, a four-minute distracter task followed the second practice set, and a five-minute distracter task followed the final practice set. These distracter tasks were the same as those used in Experiment 3 (see Appendix E7). Participants in the Control condition followed this same procedure, except that they completed a non-relevant retrieval practice task.

Following completion of the third distracter task, participants were asked to recall the names of the stolen items from the two burglaries using a cued-recall stem-completion task that was contained in an eight-page booklet. Each item was cued with a novel cue that was unique to that item. There were three cued stems on each page and participants had thirty seconds to complete each page of the recall booklet before they were prompted to move on to the next page. This recall task measured whether retrieval-induced forgetting had occurred. On completion of this task, participants were thanked, debriefed and dismissed.

Results

Retrieval Practice and Mean Recall Performance

Retrieval practice success rates for each condition were as follows: 86% ($SD = .07$) for the NRP-Similar to RP+ condition, and 84% ($SD = .10$) for the NRP-Similar to RP- condition.

Typically, the baseline measure in retrieval-induced forgetting studies is the unpracticed category (NRP items). However, as the unpracticed set has been further divided into those items that are semantically related to items from the practiced set, and items that are dissimilar to the practiced set, the NRP-Dissimilar sub-set is a more appropriate baseline measure. Table 7 displays the recall for each item type for the two experimental conditions, as well as the combined means. Mean recall across the conditions for the RP+ items was .92, while recall performance of the baseline NRP-Dissimilar items was .76, a facilitatory effect of .16. In addition, recall of the RP- items was .58, which was considerably lower than for the NRP-Dissimilar items, thus demonstrating a retrieval-induced forgetting effect of -.18. This pattern of reduced recall of RP- items relative to the baseline demonstrates the detrimental effects on memory of the prior retrieval of other items from memory, and that retrieval-induced forgetting did occur. Finally, mean recall of the NRP-Similar items was .63, which was also lower than for the NRP-Dissimilar items, demonstrating a cross-category effect of -.13. Therefore, the impaired recall of RP- and NRP-Similar items, even when novel recall cues are used, strongly suggests that inhibitory processes are responsible for these interference effects.

Transformation of Recall Scores

The recall scores (proportion correct) within each condition were transformed using arcsin transformation in order to establish homogeneity of variance for all subsequent analyses (see Snedecor & Cochran, 1980, pp. 290-291).

NRP-Similar to RP+ Condition

A single factor (item type: RP+, or RP-, or NRP-Similar items, or NRP-Dissimilar) within-subjects ANOVA demonstrated a significant main effect of item type for the NRP-Similar to RP+ condition, $F(3,87) = 30.44$, $p < .01$, $MSe = .11$. Cohen's f was calculated as an unbiased measure of effect size (Cohen, 1988), and indicates the presence of a large effect for the NRP-Similar to RP+ condition (Cohen's $f = .60$). Using Holm's sequential Bonferroni approach, a series of post-hoc pairwise comparisons revealed facilitatory effects (i.e., $RP+ > NRP-Dissimilar$, $t(29) = 4.83$, $p < .01$), retrieval-induced forgetting effects (i.e., $RP- < NRP-Dissimilar$, $t(29) = -4.159$, $p < .01$), and cross-category impairment (i.e., $NRP-Similar < NRP-Dissimilar$, $t(29) = -2.30$, $p < .05$), see Appendix H1 for statistical tables).

NRP-Similar to RP- Condition

Similar patterns were also observed in the data for the second experimental condition, where items from the NRP set were similar to RP- items. A single factor (item type: RP+, or RP-, or NRP-Similar, or NRP-Dissimilar) within-subjects ANOVA demonstrated a significant main effect of item type for the NRP-Similar to RP- condition, $F(3,87) = 26.15$, $p < .01$, $MSe = .08$. Calculations of effect size demonstrate the presence of large effects for this condition (Cohen's $f = .54$). Employing Holm's sequential Bonferroni approach, a series of post-hoc pairwise comparisons revealed that participants recalled significantly more RP+ items than NRP-Dissimilar items, $t(29) = 4.77$, $p < .01$, demonstrating the facilitatory effects of prior retrieval. Retrieval-induced forgetting effects were also found, where RP- items were recalled less than the NRP-Dissimilar items, $t(29) = -3.40$, $p < .01$. Second-order impairment was also significant, $t(29) = -2.14$, $p < .05$, with fewer NRP-Similar

items recalled compared to NRP-Dissimilar items (see Appendix H2 for statistical tables).

Table 7: Mean recall performance as a function of item types

	Item Type				Retrieval-induced Forgetting
Condition	RP+	RP-	NRP-Similar	NRP-Dissimilar	(RP-) – NRP-Dissimilar
NRP-Similar to RP+	.93 (.10)	.60 (.22)	.65 (.20)	.78 (.18)	-.18
NRP-Similar to RP-	.91 (.12)	.56 (.20)	.60 (.22)	.74 (.18)	-.18
Mean	.92 (.11)	.58 (.21)	.63 (.21)	.76 (.18)	-.18

Note. RP+ = practiced items from the practiced category. RP- = unpracticed items from the practiced category. NRP-Similar = unpracticed items from the unpracticed category that are semantically similar to items from the practiced category. NRP-Dissimilar = unpracticed items from the unpracticed category that are semantically dissimilar to items from the practiced category. NRP-Similar to RP+ = condition where a sub-set of NRP items are related to RP+ items. NRP-Similar to RP- = condition where a sub-set of NRP items are related to RP- items. Recall of items in the Control condition = .77 (SD = .12). Standard deviations are enclosed in parentheses.

Baseline Measures of Recall

A between-subjects ANOVA confirmed that participants performance on NRP-Dissimilar items (overall $M = .76$) was not significantly different from the recall performance of control participants ($M = .78$), $F(2,87) = .63$, $p = \text{n.s.}$ (see Appendix H3 for statistical table).

Discussion

In the current study, retrieval-induced forgetting was again found when the independent probe method was used as a tool for measuring recall, thereby replicating and extending the findings of Experiment 3. While the retrieval cues that were used at recall differed from those that were employed in both the study and retrieval practice phases recall performance for the RP- items was still impaired. Therefore, following M.C. Anderson and Spellman's (1995) criteria, these results suggest that inhibitory mechanisms are the primary process underlying retrieval-induced forgetting.

In addition, evidence was found that indicated the presence of cross-category inhibition. When some of the items from the NRP set were semantically similar to RP+ items, recall of these NRP-Similar items was markedly impaired in comparison to the NRP-Dissimilar items. This result suggests that items from the unpracticed category that are semantically similar to the RP+ items compete directly with the practiced items for retrieval and thus need to be inhibited. This direct competition with the target items, and their subsequent inhibition, further suggests that these NRP-Similar to RP+ items may actually act like a second RP- sub-group.

Similarly, when NRP items were semantically related to inhibited RP- items, NRP-Similar items suffered the same fate as their counter-parts. The inhibition of the NRP-Similar items occurred despite these items not sharing a cue with the RP+ items and therefore they do not compete directly with the target RP+ items for retrieval. Thus, the impaired recall of NRP-Similar to RP- items cannot easily be explained by the strength-dependent actions of non-inhibitory theories of interference. Unlike non-inhibitory theories, inhibitory theories can accommodate the second-order inhibition of NRP-Similar items that are semantically associated with the RP- items. The

pattern suppression model of inhibitory effects provides a particularly appealing account of second-order effects. The pattern suppression model assumes that memorial representations are composed of feature units and that semantically similar representations can overlap with one another resulting in the sharing of features. Should an NRP item be similar to an inhibited RP- item, the memorial representation of the NRP item may overlap with many of the inhibited features of the RP- item. Due to this sharing of inhibited features, an NRP item, which is itself unrelated to the RP+ item, may also be the focus of inhibitory processes. As with M.C. Anderson and Spellman's (1995) findings of second-order inhibition, the results of the current experiment also appear to support the pattern suppression model. However, as identifying the specific type of inhibitory model was not an aim of the current experiment (nor of this thesis), the applicability of the pattern suppression model remains a point of conjecture.

The findings within the current experiment that NRP items that are similar to either RP+ or RP- items can be subjected to inhibitory processes also has more general implications for facilitatory priming effects (e.g., Neely, 1977), and models of spreading activation (e.g., J.R. Anderson, 1983; E.F. Loftus, 1973; Roediger & McDermott, 1995). For example, the false memory effects using the Deese-Roediger-McDermott (DRM) paradigm is generally viewed as being due to the effect of spreading semantic activation. In the DRM paradigm, participants are presented with lists of semantically related items one list at a time (e.g., bed, rest, awake, tired, dream, wake, night, etc.), and either recall each list after study, or perform an unrelated filler task. After having studied all of the lists participants have to complete a recognition task that consists of list items, critical lures (i.e., non-studied items that are semantically similar to the studied items such as 'sleep'), and non-critical lures

(i.e., non-studied items that are dissimilar to the studied items such as 'bread'). Typically, participants recognise equally as many of the critical lures as they do the studied items, and this effect occurs independently of whether participants previously recalled list items or not. Roediger and McDermott (1995) have suggested that the prior study of items may lead to semantic activation spreading throughout the semantic memory network to all semantically related items. As a result of the activation of related memorial representations these items are more likely to be recognised than dissimilar items.

The finding that activation spreads to semantically similar items is not, however, necessarily incompatible with retrieval-induced forgetting and second-order inhibition if the change from facilitation to inhibition (or vice versa) is viewed as occurring on a continuum. Under many circumstances it may be more beneficial for activation to spread to related memorial representations, while in other situations it may be more beneficial for inhibition to counteract the effects of spreading activation. In paradigms such as the DRM, or the lexical decision task that can be used to study facilitatory priming effects, the spreading of semantic activation between memorial representations may be advantageous to the current goal. For example, word identification is, in general, likely to benefit greatly from priming effects (Meyer & Schvaneveldt, 1971), while in the DRM procedure, recognition of the studied items, even without prior retrieval of those items, remains quite high (Roediger & McDermott, 1995). In contrast, as the goal of the retrieval practice task is to selectively retrieve a sub-set of items from a category it may be maladaptive for semantic activation to spread from the RP+ items to the RP- or NRP-Similar items. Under such conditions, inhibition may be activated in order to counteract the spreading of semantic activation.

Having established robust retrieval-induced forgetting and cross-category inhibition (i.e., NRP-Similar to RP+ items) and second-order effects, (i.e., NRP-Similar to RP- items) the independent probe method can be applied to the modified misinformation paradigm previously used in Experiments 1a and 2b. As this technique can confirm whether the RP- and NRP-Similar items are inhibited before the introduction of misinformation it can be used to investigate the role of inhibitory processes in the production of misinformation effects. In addition, as the current experiment has demonstrated that NRP items that are related to the practiced category are also subjected to inhibition, the inclusion of the independent probe method within the modified misinformation paradigm can determine whether all inhibited information is ultimately susceptible to misleading information.

CHAPTER 9

EXPERIMENT 5: INHIBITORY PROCESSES AND THE MISINFORMATION
EFFECT

Having established the groundwork for inhibitory processes in retrieval-induced forgetting through the use of the independent probe method, as well as the presence of cross-category and second-order impairment, the role of inhibition in the misinformation effect can now be investigated. The current chapter describes the fifth and final experiment, which attempts to apply the independent probe method to the modified misinformation paradigm in order to examine whether inhibitory mechanisms can be responsible for misinformation effects.

While the misinformation effect can be used as a method for studying the processes involved in memory updating this avenue of research has remained largely ignored. As a result, the mechanisms that may underlie the misinformation effect and the possible role of these processes in the updating of memory have yet to be determined. Both supporters of the trace alteration and trace coexistence account of misinformation effects have advanced general ideas concerning how misinformation effects may occur, but very little research has specifically sought out to examine possible mechanisms.

During E.F. Loftus' earlier research she proposed a destructive updating mechanism as the most likely cause of the misinformation effect (e.g., E.F. Loftus, 1979a; E.F. Loftus et al., 1978). As E.F. Loftus and colleagues believed that only one representation of an event could be stored in memory, such a mechanism was thought to update the initial memory through the erasure of the original information (e.g., E.F. Loftus, 1979a; E.F. Loftus & Loftus, 1980). The misleading item was then thought to

replace the original item. Although E.F. Loftus has since revised this rather extreme view of trace alteration to include a weakening or disintegration of the features of the original trace on the introduction of the misleading item (E.F. Loftus & Hoffman, 1989) the mechanisms by which this alteration occurs remain unspecified. Other than the possible deleterious effects of the passage of time on memorial representations (E.F. Loftus et al., 1978) E.F. Loftus has advanced few specific details concerning how a destructive updating process would achieve the misinformation effect.

Various retrieval accounts have also been proposed as possible explanations to the misinformation effect but these accounts have also remained insufficiently specified concerning the exact mechanisms by which misinformation effects occur. For example, while Bekerian and Bowers (1983) suggest that the misinformation effect may be due to a mismatch between encoding and retrieval cues their conclusions remain rather general. As a result, the possibility that this mismatch in cues may be due to non-inhibitory processes and, therefore, that some misinformation effects may be due to cue-dependent forgetting, remain relatively unexplored.

Perhaps one of the few researchers to more thoroughly explore the underlying mechanisms is Chandler and colleagues who have identified several possible retrieval processes (e.g., Chandler, 1991; Chandler and Gargano, 1998; Chandler et al., 2001). Critically, Chandler and colleagues identified that misinformation effects are most likely to occur under conditions where the original and misinformation trace share the same retrieval cue (i.e., A-B, A-D paradigm) and the misinformation trace is accessed prior to that of the original trace during the retrieval process. From these initial principles, Chandler and colleagues have proposed at least three possible retrieval processes that may lead to the misinformation item being chosen at test. Cue-change, blocking and the discrimination account attempt to explain misinformation effects as

being the result of various non-inhibitory mechanisms. Each of these accounts suggests that interference may occur at the level of the retrieval cues or along the retrieval routes, and as a result, are all examples of cue-dependent forgetting. Due to their cue-dependent nature, the accounts of cue-change, blocking and discrimination all suggest that misinformation effects can be avoided if the original trace can be selectively activated by the retrieval cue.

The non-inhibitory account of misinformation effects suggested by Chandler and colleagues may be one of the few examples of true impairment in memory for an event, as well as implicating impairment occurring at the level of the retrieval cues and retrieval routes. This is quite an important observation given that some researchers have suggested that the misinformation effect may not be an indicator of genuine memory impairment at all (e.g., McCloskey & Zaragoza, 1985a). Rather, the misinformation effect may only represent a change in performance by misled participants. The fact that the majority of misinformation studies measure the effects of misleading information through comparing misled performance with control performance, nor have they employed specific techniques for examining possible mechanisms, in anyway lessen this concern. Thus, this potential problem concerning the misinformation effect may explain why over three decades of research has been unable to provide any real degree of insight into the underlying mechanisms of the misinformation effect.

Perhaps the first to raise concern over the misinformation effect was McCloskey and Zaragoza (1985a) who suggested that the demand characteristics and guessing biases that are inherent to the typical misinformation paradigm make it unsuitable for addressing whether misleading information impairs memory. McCloskey and Zaragoza suggest that specific questions concerning memory

impairment in the misinformation effect must be addressed through the use of a modified recognition test that removes the misleading item as a choice at test. By removing the misleading item the rates of guessing and the effects of demand characteristics should be equalised across misled and control conditions.

While the modified test may allow us to investigate whether misinformation impairs memory for the original item it, however, tells us little about the underlying mechanisms that may be responsible for memory impairment. Given that moderately-sized misinformation effects have been found using the modified test (Belli et al., 1992; Ceci et al., 1987; Chandler, 1989, 1991; Chandler & Gargano, 1998; Toglia et al., 1992), it would appear that misinformation can still impair memory even after demand characteristics and guessing rates are controlled for. Thus, what processes could be responsible for such effects?

Similarly, Schooler and Tanaka (1991) have raised concerns over whether the representation of blended memories within a composite memory model (i.e., CHARM, Metcalfe, 1990) represent a change in performance on a test (i.e., performance blends), or a change to the underlying memorial representations (i.e., representational blends). Despite Schooler and Tanaka describing performance and representational blends as being two possible causes of blended memories in CHARM the basic premise may also be applied more generally to the misinformation literature. Performance blends could explain the misinformation effect as being due to post-event information filling in 'gaps' in memory for the original event and, thus, acting as supplementary information. Thus, under such conditions, the misleading information would not necessarily constitute contradictory information, but rather, memory may treat it as addition information that updates the initial representation of the event. Due to the similar nature of the original event and the post-event

information participants may be unable to detect which parts of their memory for the event comes from which source. As a result, choosing the misleading item at test is unlikely to be the result of any true memory impairment (either through trace alteration or a change in the retrieval availability of memorial representations), nor does it tell us a great deal about the mechanisms underlying the memory updating process. Conversely, the misinformation effect could truly represent genuine impairment in memory through changes occurring at the level of the memorial representations. In order to address specifically this latter point, however, a suitable experimental procedure is required, such as the independent probe method.

The Inhibitory Account of Misinformation Effects

Taking into account these prior problems concerning whether the misinformation effect represents genuine memory impairment occurring at the level of the memorial representations, the inhibitory account attempts to re-address these concerns through the adaptation of the modified misinformation paradigm. More specifically, in order to examine whether inhibitory processes can be responsible for misinformation effects, and if this impairment occurs at the level of the memorial representations, the independent probe method needs to be employed within the modified misinformation paradigm.

In contrast to the modified test, adapting the independent probe method for use with the modified misinformation paradigm can not only equalise demand characteristics and guessing rates across conditions but it can also directly measure possible underlying mechanisms to the misinformation effect. As a result, such a paradigm should have the ability to separate the actions of non-inhibitory processes from that of inhibitory processes. In addition to this, if inhibitory processes are found

to be responsible for misinformation effects then the independent probe method can also measure what stage during the retrieval process this inhibition occurs. Specifically, the independent probe method can determine whether the memorial representation of the original item is itself subjected to inhibition.

As Chandler and colleagues research suggests that there can be multiple mechanisms involved in the production of misinformation effects (see also Belli, 1989), it is possible that inhibitory processes may provide an additional mechanism by which misleading information becomes integrated into memory. If it is indeed the case that inhibitory processes are implicated in the misinformation effect, an inhibitory account may also have some advantages over a non-inhibitory account. Such differences can perhaps be seen more clearly in the differing predictions made by both the inhibitory and non-inhibitory accounts. For example, the non-inhibitory account assumes that misinformation effects are due to the accessing of the misleading trace (during the post-event information phase) just prior to test making this trace much more accessible than the original trace during the memory test (e.g., Chandler, 1991; Chandler and Gargano, 1998; Chandler et al., 2001). However, in the inhibitory account the prior access of the misleading trace before test is not a necessary requirement, and as such, the misinformation effect may still occur even when the post-event information phase occurs *before* the study phase (i.e., the misleading item is presented before the original item). Thus, the inhibitory account predicts the *reversed misinformation effect* (Abeles & Morton, 1999; Lindsay & Johnson, 1989b).

Another critical difference between the inhibitory and non-inhibitory accounts concerns the original and misleading trace sharing a retrieval cue. While the sharing of retrieval cues is a critical condition in the production of misinformation effects in

non-inhibitory accounts the original and misleading item do not have to share a cue in the inhibitory account. So long as the misleading item is at least consistent with the overall theme of an event then the misinformation can be very different to the original item. Specifically, while an individual may reject misleading information that is inconsistent with an event (e.g., introducing post-event information concerning a car into an event about an office theft) the inhibitory account would predict that semantically dissimilar misleading information may be successfully introduced on an original item (e.g., the misleading item 'wallet' is introduced on 'coffee machine'). Similarly, while non-inhibitory accounts predict stronger interference effects from semantically similar misleading information the inhibitory account makes no such prediction. In fact, the only critical conditions necessary in the inhibitory account for the production of the misinformation effect is that inhibition be present and that it be directed at the original item. Thus, if inhibitory processes can provide an additional route to misinformation effects, it would not only be able to explain many previously unaccounted misinformation effects, but also suggest that misleading post-event information can perhaps have more widespread deleterious effects.

Hypotheses

If inhibitory processes are found to be present, then significantly more misinformation effects should be found in conditions where misinformation is introduced on inhibited items than in conditions where it is introduced on non-inhibited items. Under conditions where misleading information is presented on an inhibited item then misled participants are unlikely to be able to bring that original item into conscious awareness and, therefore, are likely to choose the misinformation on a memory test. In contrast, participants who receive misinformation on a non-inhibited item are more

likely to choose the original item on a memory test as these participants can easily examine their memory for an event and locate the original information.

More specifically, inhibitory theories predict that *all* information that has been inhibited will be susceptible to misinformation. This is irrespective of whether the original information belongs to the target event (i.e., the one the participant is questioned about in the retrieval practice phase) or not. This being so, if inhibition is the determining factor for the successful assimilation of misinformation into event memory, then information from the unpracticed house that has been inhibited (i.e., NRP-Similar to RP+ and NRP-Similar to RP- items) should also be susceptible to post-event misleading information. As NRP-Similar items that are related to either the RP+ sub-set or RP- sub-set are likely to be inhibited by the retrieval of the target practiced items, misled participants are less likely to choose NRP-Similar items on a memory test. The findings of increased misinformation effects on NRP-Similar items would strongly suggest that inhibition may be a critical determinant of the misinformation effect, and that information of little relevance to an event can still be susceptible to misleading information. On the other hand, if misinformation is introduced on a non-inhibited item, such as an NRP-Dissimilar item or a Control item, then significant misinformation effects are not expected due to the original target item remaining available in memory.

Method

Participants and Design

One hundred and fifty students and members of the public (77 men and 73 women) participated on a voluntary basis in this study. The experiment had a single factor

(misinformation item: NRP-Similar to RP+, NRP-Similar to RP-, NRP-Dissimilar, RP-, or Control) between-subjects design where misinformation was introduced on either an NRP item similar to RP+ items, or an NRP item similar to the RP- items, NRP items dissimilar to the retrieval practice category, RP- items, or Control items. Each condition contained 30 participants.

Materials

Study Materials

The study materials used in the presentation phase were identical to those used in Experiment 4 (see Appendix G1).

Retrieval Practice Questions

The retrieval practice booklets were identical to those used in Experiment 4 (see Appendix G2). In the NRP-Similar to RP+ condition, half of the items from the implicit sub-categories formed part of the RP+ set in order for the remaining implicit sub-category members in the NRP set to be related to RP+ items (i.e., NRP-Similar items). In the NRP-Similar to RP- condition, half of the items from the implicit sub-categories formed part of the RP- set in order for the remaining implicit sub-category members in the NRP set to be related to these RP- items (i.e., NRP-Similar items). Participants in the Control condition did not receive a retrieval practice task about any of the stolen items. Rather, they received the same non-relevant retrieval practice task that was used in the Control condition of Experiment 1a (e.g., the capital city of Cuba is Ha_____), see Appendix A4.

Recall Booklets

The stem completion task that was employed in the previous studies was changed from a two-letter stem to a one-letter stem due to the extremely high recall rates recorded across all item types in the previous study. To ensure that this alteration in stem length would not lead to the task becoming too difficult and result in floor effects, a pilot study was run, in which ten participants completed the study phase, a ten-minute distracter task (three sets of anagrams, see Appendix E7), and the 8 page recall booklet that used the same cues as the previous experiment, with the new one-stem prompts. Average recall using this technique was 71.66% ($SD = .08$). Therefore, cues with one-letter stems were used to measure recall performance in this study (see Appendix II).

Additional Questioning and Misinformation Phase

Each participant received only one piece of misinformation in order to reduce the chances of suspicion being raised about the true nature of the experiment. In addition, the misinformation was embedded in one of twelve questions about one of the burglaries (the name of the house, Thompson's or Williams', appeared in each question). These questions referred to details that were neither the subject of the retrieval practice phase or formed the basis of the final memory test that measured the influence of the misinformation. All participants received questions concerning the practiced house (i.e., the house from which its items formed the basis of the retrieval practice task). Participants in the NRP-Similar to RP+ condition received a piece of misinformation targeted at an item from unpracticed house (i.e., non-target house) that was similar to RP+ items and thus was also an item from one of the implicit sub-categories. Participants in the NRP-Similar to RP- condition received a piece of

misinformation targeted at an item from the unpracticed house that was similar to RP-items, and thus was also a member of one of the implicit sub-categories. Participants in the NRP-Dissimilar condition received misinformation on an item from the unpracticed house that was dissimilar to all items from the practiced house and thus was not a member of any of the implicit sub-categories. Participants in the RP-condition received misinformation about an unpracticed item from the practiced house (i.e., target house) that was also a member of one of the implicit sub-categories. For participants in the Control condition, choice of misinformation and, therefore, which burglary they received questions about, was randomised and counterbalanced. In the absence of a previous retrieval practice session, this particular condition acted as a baseline measure for the misinformation effect. The misinformation item was semantically related in each case to the critical item, as determined through previous pilot work, see Appendix I2 for a list of all misinformation items and questions⁶.

Forced-Choice Recognition Task

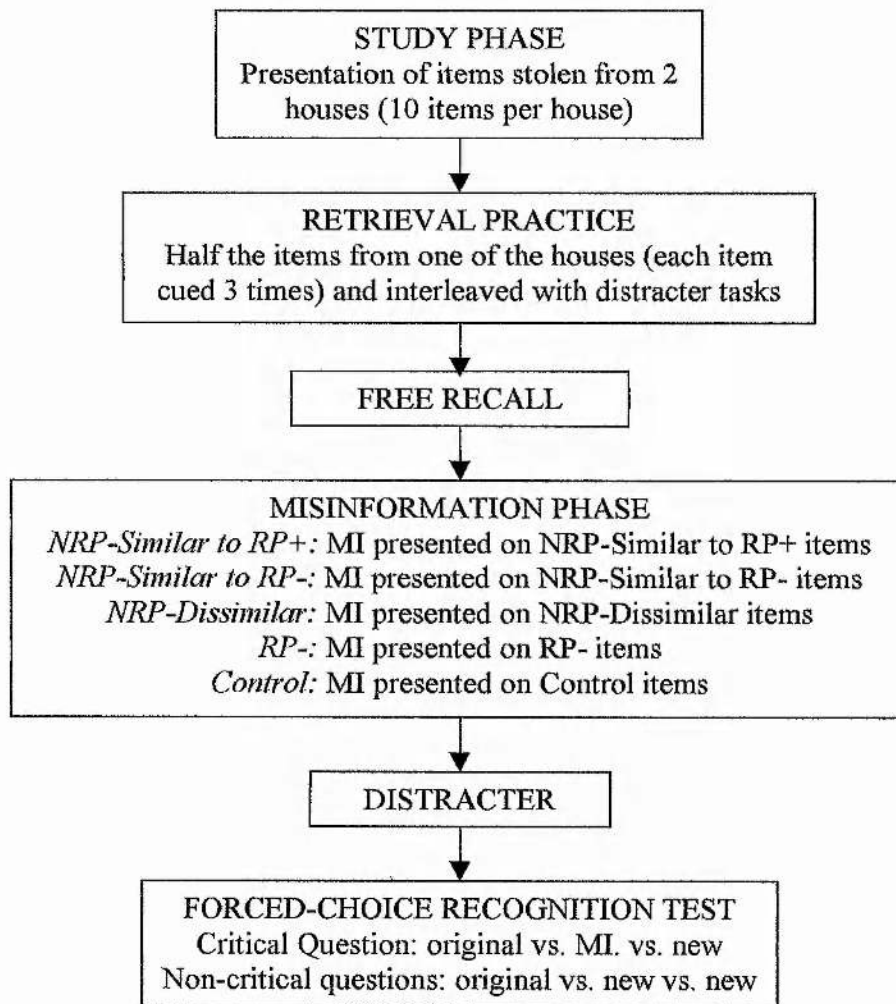
The misinformation effect was measured using a set of multiple-choice questions. There were eight questions containing three possible answers (the correct item and two novel items), and participants had to circle one item for each question. For the critical question measuring the effect of introducing misinformation, participants had to choose between the correct item, the misinformation item, or a novel item (see Appendix I3).

⁶ This information was taken from the pilot study described in Experiment 3, see Appendix E1.

Procedure

Participants arrived at the laboratory individually or in groups of up to four, were greeted by a female experimenter, and randomly assigned to one of the testing conditions. Participants were informed that they were to take part in a memory task. The study, retrieval practice and recall phases were the same as Experiment 4, except for the use of the one-letter stems during cued recall. Following completion of the recall task, participants were presented with twelve additional questions about one of the burglaries. Embedded in one of the questions was a single piece of post-event misinformation. Participants had four minutes to complete these questions. Following this, participants were presented with a distracter task, where they had to write down the names of ten countries for each letter of the alphabet. Participants were given five minutes for this task, and no participants completed this task in the allocated time. Finally, participants were presented with the forced-choice recognition task that measured the impact of misinformation on memory. Participants had to choose the correct stolen item from a choice of the original item, and two novel items for non-critical items. For the critical question that measured the misinformation effect, participants had to choose the correct item from a choice of the original item, the misinformation item, and a novel item. This final memory task was not timed, and participants could take as long as they needed in order to complete it. Once participants had finished, they were thanked, debriefed and dismissed (see Figure 31 for an outline of the procedure of this experiment).

Figure 31: Outline of procedure for Experiment 5



Note. MI = Misinformation

Results

Retrieval Practice Success and Mean Recall Performance

Retrieval practice success rates for each condition were as follows: 85% ($SD = .09$) for the NRP-Similar to RP+ condition, 89% ($SD = .07$) for the NRP-Similar to RP- condition, 87% ($SD = .10$) for the Dissimilar condition, and 90% ($SD = .08$) for the RP- condition.

Table 8 displays the recall for each item type for the four experimental conditions, including standard deviations, as well as their combined means. Mean recall across the conditions for the RP+ items was .84, while recall performance of the baseline NRP-Dissimilar items was .65, a facilitatory effect of .19. In addition, recall of the RP- items was .49, which was considerably lower than for the NRP-Dissimilar items, thus demonstrating a retrieval-induced forgetting effect of -.16. This pattern of reduced recall of RP- items relative to the baseline demonstrates the deleterious effects that prior practice has on memory for other items. Finally, mean recall of the NRP-Similar items was .51, which was also lower than for the NRP-Dissimilar items, demonstrating a cross-category/second-order effect of -.14. Therefore, the impaired recall of RP- and NRP-Similar items, even when novel recall cues are used, strongly suggests that inhibitory processes are responsible for these interference effects.

Transformation of Data

The recall scores (proportion correct) within each condition were transformed using arcsin transformation in order to establish homogeneity of variance for all subsequent analyses (see Snedecor & Cochran, 1980, pp. 290-291).

Table 8: Mean recall performance as a function of item type

Condition	Item Type				Retrieval-induced Forgetting
	RP+	RP-	NRP-Similar	NRP-Dissimilar	(RP-) – NRP-Dissimilar
NRP-Similar to RP+	.86 (.10)	.49 (.15)	.53 (.27)	.66 (.20)	-.17
NRP-Similar to RP-	.83 (.13)	.48 (.21)	.48 (.25)	.64 (.19)	-.16
NRP-Dissimilar	.83 (.12)	.50 (.22)	.51 (.24)	.65 (.18)	-.15
RP-	.85 (.14)	.49 (.21)	.53 (.20)	.66 (.21)	-.17
Mean	.84 (.12)	.49 (.20)	.51 (.24)	.65 (.20)	-.16

Note. RP+ = practiced items from the practiced category. RP- = unpracticed items from the practiced category. NRP-Similar = unpracticed items from the unpracticed category that are semantically similar to items from the practiced category. NRP-Dissimilar = unpracticed items from the unpracticed category that are semantically dissimilar to items from the practiced category. Recall of items in the Control condition = .71 (SD = .10). Standard deviations are enclosed in parentheses.

Manipulation Check: Retrieval-induced Forgetting

NRP-Similar to RP+ Condition

Table 8 displays the recall for each item type for all experimental conditions. Mean recall of the RP+ items was .86, while recall performance for the NRP-Dissimilar items was .66 demonstrating the positive effects of practice on recall. However, recall of the RP- items was much lower at .49, and adequately demonstrates the negative

effects of retrieval on related information. This pattern was further observed between the NRP-Similar and NRP-Dissimilar items, with recall performance for NRP-Similar items only .53.

A single factor (item type: RP+, or RP-, or NRP-Similar, or NRP-Dissimilar) within-subjects ANOVA demonstrated a significant main effect of item types for the NRP-Similar to RP+ condition, $F(3,87) = 18.93, p < .01, MSe = .10$. Cohen's f indicated the presence of large effects for this condition ($f = .43$). Using Holm's sequential Bonferroni approach, a series of pairwise comparisons revealed the facilitatory effects of practice on recall (i.e., $RP+ > NRP-Dissimilar, t(29) = 3.16, p < .01$), and the detrimental effect on related but unpracticed members of the same category (i.e., $RP- < NRP-Dissimilar, t(29) = -4.42, p < .01$). In addition, evidence was found for cross-category impairment, whereby fewer items from the unpracticed category that were semantically similar to the practiced items were recalled compared to the remaining dissimilar items from the unpracticed category (i.e., $NRP-Similar < NRP-Dissimilar, t(29) = -2.07, p < .05$) see Appendix J1 for statistical tables.

NRP-Similar to RP- Condition

Mean recall of the RP+ items was .83, while recall performance of the NRP-Dissimilar items was .64 demonstrating the positive effects of practice on recall. However, recall of the RP- item was only .48 and adequately demonstrates the negative effects of retrieval on related information. This pattern was further observed between items from the NRP-Similar and NRP-Dissimilar items with recall performance for NRP-Similar items only .48.

A single factor (item type: RP+, or RP-, or NRP-Similar, or NRP-Dissimilar) within-subjects ANOVA demonstrated a significant main effect of item types for the

NRP-Similar to RP- condition, $F(3,87) = 21.11$, $p < .01$, $MSe = .09$. Cohen's f indicated the presence of large effects for this condition ($f = .46$). Using Holm's sequential Bonferroni approach, a series of pairwise comparisons revealed the facilitatory effects of practice on recall (i.e., $RP+ > NRP$ -Dissimilar, $t(29) = 3.85$, $p < .01$), and the detrimental effect on related but unpracticed members of the same category (i.e., $RP- < NRP$ -Dissimilar, $t(29) = -2.99$, $p < .01$). In addition, evidence was found for second-order inhibition, whereby fewer items from the unpracticed category that were semantically similar to the unpracticed items from the practiced category were recalled compared to the remaining dissimilar items from the unpracticed category (i.e., NRP -Similar $< NRP$ -Dissimilar, $t(29) = -3.15$, $p < .01$), see Appendix J2 for statistical tables.

NRP-Dissimilar Condition

Mean recall of the $RP+$ items was .83, while recall performance of the NRP -Dissimilar items was .65 demonstrating the positive effects of practice on recall. However, recall of the $RP-$ items was only .50, demonstrating the negative effects of retrieval on related information. This pattern was further observed between NRP -Similar and NRP -Dissimilar items with recall of NRP -Similar items only .51.

A single factor (item type: $RP+$, or $RP-$, or NRP -Similar, or NRP -Dissimilar) within-subjects ANOVA demonstrated a significant main effect of item type for the NRP -Dissimilar condition, $F(3,87) = 19.35$, $p < .01$, $MSe = .08$. Cohen's f indicated the presence of large effects for this condition ($f = .44$). Using Holm's sequential Bonferroni approach, a series of pairwise comparisons revealed the facilitatory effects of practice on recall (i.e., $RP+ > NRP$ -Dissimilar, $t(29) = 4.03$, $p < .01$), and the detrimental effect on related but unpracticed members of the same category (i.e., $RP-$

< NRP-Dissimilar, $t(29) = -2.54, p < .05$). In addition, evidence was found for cross-category/second-order inhibition, whereby fewer items from the unpracticed category that were semantically similar to the items from the practiced category were recalled compared to the remaining dissimilar items from the unpracticed category (i.e., NRP-Similar < NRP-Dissimilar, $t(29) = -2.20, p < .05$), see Appendix J3 for statistical tables.

RP- Condition

Mean recall of the RP+ items was .85, while recall performance of the NRP-Dissimilar items was .66 demonstrating the positive effects of practice on recall. However, recall of the RP- items was only .49, and demonstrates the negative effects of retrieval on related information. This pattern was further observed between the NRP-Similar and NRP-Dissimilar items with recall of NRP-Similar items only .53.

A single factor (item type: RP+, or RP-, or NRP-Similar, or NRP-Dissimilar) within-subjects ANOVA demonstrated a significant main effect of item type for the RP- condition, $F(3,87) = 23.29, p < .01, MSe = .01$. Cohen's f indicated the presence of large effects for this condition ($f = .50$). Using Holm's sequential Bonferroni approach, a series of pairwise comparisons revealed the facilitatory effects of practice on recall (i.e., RP+ > NRP-Dissimilar, $t(29) = 4.42, p < .01$), and the detrimental effect on related but unpracticed members of the same category (i.e., RP- < NRP-Dissimilar, $t(29) = -2.93, p < .01$). In addition, evidence was found for cross-category/second-order inhibition, whereby fewer items from the unpracticed category that were semantically similar to items from the practiced category were recalled compared to the remaining dissimilar items from the unpracticed category (i.e., NRP-

Similar < NRP-Dissimilar, $t(29) = -2.82$, $p < .01$), see Appendix J4 for statistical tables.

Baseline Measures of Recall

A between-subjects ANOVA confirmed that participants performance on NRP-Dissimilar items (overall $M = .65$) was not significantly different from the recall performance of Control participants ($M = .71$), $F(4, 145) = .42$, $p = \text{n.s.}$, $MSe = .09$. (see Appendix J5 for statistical tables).

Misinformation Effects

After having confirmed the presence of inhibitory processes underlying the retrieval-induced forgetting effect in each of the four experimental conditions, the effects of introducing misinformation on items that vary in their activation status (i.e., inhibition versus non-inhibition) can be considered. As inhibitory theories predict that participants are more likely to choose the misleading item when it is presented on an inhibited item, significant misinformation effects are only expected in the RP-, NRP-Similar to RP+, and NRP-Similar to RP- conditions. This hypothesis was confirmed. The largest misinformation effects occurred in the NRP-Similar to RP- condition, where 67% of participants chose the misinformation item over the correct original item (see Figure 32). Similarly, in the RP- and NRP-Similar to RP+ conditions, participants chose the misinformation item 57% and 47% of the time, respectively (see Table 9 for proportion of participants choosing the original, misinformation, or new item at test).

A chi square analysis was conducted to evaluate whether misinformation had a more deleterious effect in conditions where misleading information was introduced on

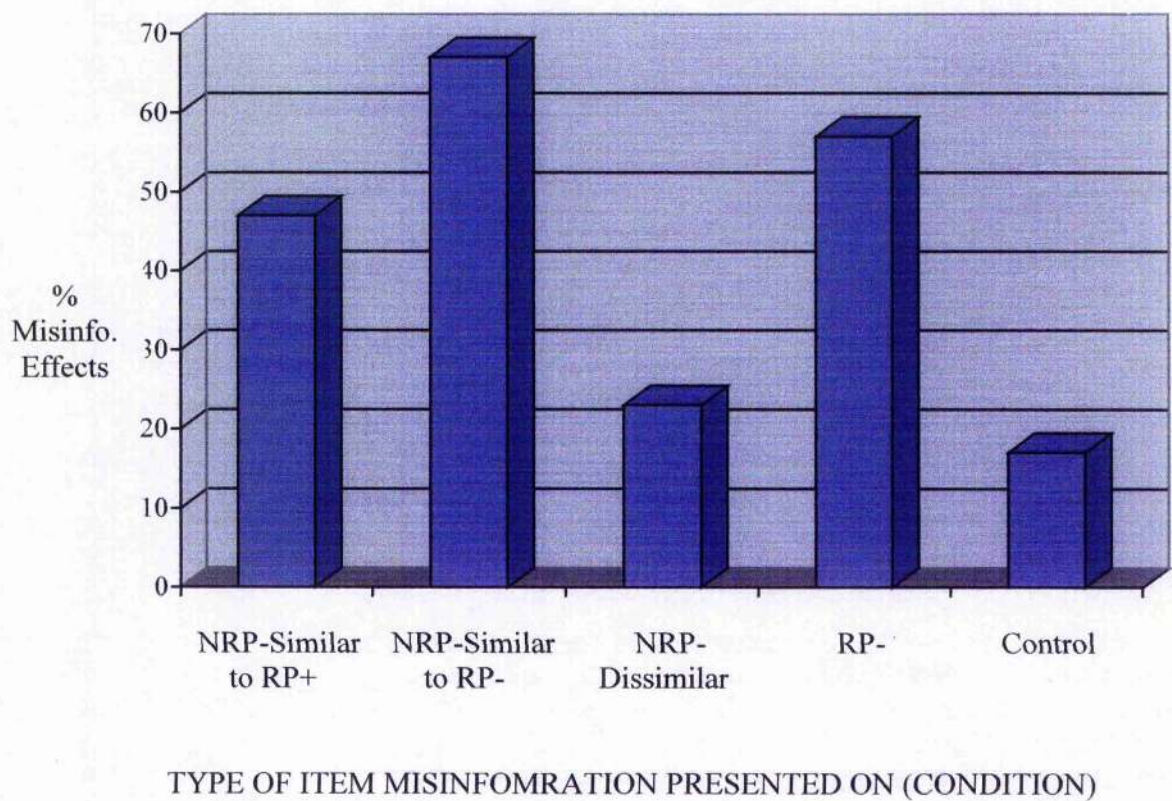
items that were subjected to inhibition. Condition and misinformation effect were found to be significantly related, $\chi^2(4, n = 100) = 22.61, p < .01$ (see Appendix J6). Effect size was computed Phi ($\Phi = .39$) which indicated the presence of a medium sized effect.

Table 9: Likelihood of participants choosing the correct original item, the misinformation items, and the new item during forced-choice recognition

Condition	Critical item			Non-critical items
	Original	Misinfo.	New error	Mean Error
NRP-Similar to RP+	.40	.47	.13	.07 (.11)
NRP-Similar to RP-	.30	.67	.03	.04 (.08)
NRP-Dissimilar	.73	.23	.03	.07 (.11)
RP-	.43	.57	.00	.08 (.08)
Control	.83	.17	.00	.05 (.08)

Note. NRP-Similar to RP+: were misinformation was presented on NRP-Similar items that were related to RP+ items. NRP-Similar to RP-: were misinformation was presented on NRP-Similar items that were related to RP- items. NRP-Dissimilar: were misinformation was presented on NRP items that were dissimilar to the practiced category. RP-: were misinformation was presented on RP- items. Control: where no relevant retrieval practice occurred and misinformation was randomly presented. For the critical question measuring the misinformation effect, participants had to choose from the correct original item, the misinformation, and a new erroneous item. Proportion of errors on non-critical items (i.e., original item vs. new item vs. new item) is also included as a baseline measure of the proportion of errors made at forced-choice recognition. Standard deviations are enclosed in parentheses.

Figure 32: Percentage of participants choosing the misinformation option at forced-choice recognition in Experiment 5



Additional pairwise comparisons between the control and experimental conditions confirmed that misinformation had its greatest impact when it was presented on inhibited items, NRP-Similar to RP+: $\chi^2(1, n = 60) = 6.24, p < .05$; NRP-Similar to RP-: $\chi^2(1, n = 60) = 15.43, p < .01$; RP- $\chi^2(1, n = 60) = 10.34, p < .01$. Effect size was calculated for each comparison using Phi (NRP-Similar to RP+: $\phi = .32$; NRP-Similar to RP-: $\phi = .54$; RP- $\phi = .42$), indicating the presence of a medium effect for the NRP-Similar to RP+ condition, a large effect for the NRP-Similar to RP- condition, and a medium effect for the RP- condition (see Appendix J7

for statistical tables). In addition, no significant differences were found between any of these conditions (NRP-Similar to RP+ versus NRP-Similar to RP-: $\chi^2(1, n = 60) = 2.44, p = \text{n.s.}$; NRP-Similar to RP+ versus RP-: $\chi^2(1, n = 60) = .60, p = \text{n.s.}$; NRP-Similar to RP- versus RP-: $\chi^2(1, n = 60) = .64, p = \text{n.s.}$, see Appendix J8 for statistical tables).

In contrast, inhibitory theories predict that very few participants will choose the misleading item when it is introduced on non-inhibited items. This hypothesis was also supported, with participants in the NRP-Dissimilar and Control conditions choosing the misinformation item only 23% and 17% of the time, respectively. Chi square analysis confirmed there were no differences in the proportion of misinformation effects reported between the NRP-Dissimilar and Control conditions, $\chi^2(1, n = 60) = .42, p = \text{n.s.}$ (see Appendix J9 for statistical table).

Therefore, it appears that any information that creates competition at retrieval will be subject to inhibition which, in turn, greatly increases the likelihood of participants reporting misinformation at test. This conclusion is further strengthened when only these participants who demonstrated retrieval-induced forgetting are considered. Sixty-three percent of participants in the NRP-Similar to RP+ condition who exhibited retrieval-induced forgetting ($n = 19$) chose the misinformation over the original item, compared with 18% of participants when retrieval-induced forgetting was absent ($n = 11$). Similar patterns were also found in the two other conditions where misinformation was presented on inhibited items. In the NRP-Similar to RP- and RP- conditions, participants chose the misinformation when retrieval-induced forgetting was present 86% ($n = 22$) and 74% ($n = 19$) of the time, respectively. However, when retrieval-induced forgetting was absent, participants in the NRP-Similar to RP- condition chose the misinformation only 13% ($n = 8$) of the time,

while participants in the RP- conditions chose the misinformation only 27% ($n = 11$) of the time. Retrieval-induced forgetting should not have this varying effect on the misinformation effect in conditions where misinformation is introduced on a non-inhibited item. This observation was supported by the findings in the NRP-Dissimilar condition where participants who chose the misinformation at a comparable level regardless of whether retrieval-induced forgetting was present or absent. Twenty-two percent of participants ($n = 18$) exhibiting retrieval-induced forgetting chose the misinformation, while 25% ($n = 12$) chose the misinformation when retrieval-induced forgetting was absent. Therefore, not only are participants 3-4 times more likely to choose the misinformation item over the original item when it is presented on an inhibited item (i.e., RP-, NRP-Similar), participants are also nearly 3-7 times more likely to choose the misinformation when retrieval-induced forgetting is present than when it is absent.

In addition, there was no differences in performance on the forced-choice recognition task for non-critical items between any of the conditions (93%, 96%, 93%, 92%, 95% correct for the NRP-Similar to RP+, NRP-Similar to RP-, NRP-Dissimilar, RP-, and Control conditions, respectively). Therefore, the misinformation effects found in the conditions where misleading information was introduced on items confirmed as inhibited was not due to poor overall test performances, which may have indicated a failure to encode the target information at study.

Discussion

Having established in Experiment 3 that the memorial representation of RP- items were actively inhibited, as well as demonstrating both cross-category and second-order inhibitory effects in Experiment 4, the current study focused on whether the

inhibitory state of the original item was a critical determinant of the success of introducing misinformation. This was accomplished through the application of the independent probe method (M.C. Anderson & Spellman, 1995) to the modified misinformation paradigm, which could confirm whether the original item was inhibited or not before misleading post-event information was introduced on it.

In support of the inhibitory account, significant retrieval-induced forgetting effects were found using the independent probe method in all four of the experimental conditions (i.e., NRP-Similar to RP+ condition, NRP-Similar to RP- condition, NRP-Dissimilar condition, RP- condition). Not only does this finding suggest that inhibitory processes are responsible for retrieval-induced forgetting, but it also suggests that the memorial representations of RP- items are inhibited. The inhibition of the memorial representations of RP- items is likely the result of their direct competition for retrieval with the practiced items (i.e., the RP+ and RP- items belong to the same event).

Additionally, cross-category and second-order impairment was also found. That is, recall of NRP items that were semantically similar to RP+ items (i.e., NRP-Similar to RP+) or RP- items (i.e., NRP-Similar to RP-) were also impaired. As these findings were still found using the independent probe method it strongly suggests that the memorial representations of NRP-Similar items were also inhibited. More specifically, NRP-Similar to RP+ items are still subject to inhibition even though they appear in an unrelated event. As these items share a sub-category with the practiced items, they may compete directly for retrieval with the RP+ items in a similar manner to that of the RP- items (in effect, making this group a second RP- category). As a result of this competition, these NRP-Similar to RP+ items will be inhibited. In contrast, the NRP-Similar to RP- items do not compete directly with the RP+ items

for retrieval, but do instead share a related sub-category with the RP- items. As RP- items are inhibited to prevent them from interfering with the retrieval of the RP+ items (and this is confirmed using the independent probe method), inhibition is thought to leak to any other items that are related to the RP- items. This inhibitory account of the impaired recall of the NRP-Similar to RP- items is also supported by the observation that the strength-dependent competition assumptions of gvvnon-inhibitory theories are unable to explain this finding, as well as the unimpaired recall of the NRP-Dissimilar items. These items were unrelated to any of the items from the practiced category and so will not have competed for retrieval with the RP+ items. Therefore, NRP-Dissimilar items were not subject to inhibition and were recalled at a similar level to that of the Control items.

The introduction of misleading post-event information had a further (impairing) effect on memory performance but only for inhibited items. Misinformation had its greatest impact when presented on items that were determined to have been inhibited before misleading information was presented (i.e., NRP-Similar to RP+, NRP-Similar to RP- and RP- items). Thus, when participants were faced with the critical question on the forced-choice recognition task measuring the misinformation effect, the original target item was unavailable in memory and unable to compete with the misinformation. Under these conditions, participants chose the misinformation item. Additionally, there were no significant differences between the proportion of misinformation effects between any of these conditions despite the differences in each of the item type's relationship to RP+ items.

Further support for the inhibitory account of misinformation effects was found when only participants who demonstrated retrieval-induced forgetting were considered. That is, each condition can be divided into those participants who

demonstrate retrieval-induced forgetting (i.e., the specific inhibition of the memorial representations of the RP- items) and those who do not. Those participants who received misinformation on an inhibited item in addition to retrieval-induced forgetting also being present (i.e., RP- items were inhibited) were 3-7 times more likely to choose the misleading item at test than participants who received misinformation on an inhibited item but fail to demonstrate retrieval-induced forgetting (i.e., RP- item was unlikely to have been inhibited).

Similarly, significant misinformation effects were not detected in conditions where misinformation was presented on non-inhibited items (i.e., NRP-Dissimilar and Control items), and in the case of the NRP-Dissimilar items, this was regardless of whether retrieval-induced forgetting was present or not. This finding suggests that the NRP-Dissimilar and Control items were still available in memory at the time of the forced-choice recognition test and, as a result, were able to compete for retrieval with the misinformation item. As such items were available in memory participants were able to choose that item on the recognition test and correctly discard the misinformation item.

These findings strongly suggest that information that has been actively inhibited through the retrieval process is highly susceptible to misinformation and thus inhibitory processes are likely to be at least one of the mechanisms that mediates the misinformation effect. As a result, these findings may have a more general application to theories of memory updating. The inhibitory account suggests that the process of updating memory may be much easier when potentially unwanted or out-of-date information is first inhibited. This first step in the updating process may decrease the likelihood of older material interfering with the encoding or retrieval of newer information, while the potentially deleterious effects of non-inhibited

information on the memory updating process can be clearly seen in the NRP-Dissimilar and Control conditions. In these conditions, the memorial representations of the original items have not been subjected to inhibition, and as a result, post-event information is unsuccessfully introduced on NRP-Dissimilar and Control items. In terms of memory updating, these findings suggest that the updating process may be relatively unsuccessful if the unwanted or out-of-date information is not first suppressed.

As the retrieval process appears to play a key role in retrieval-induced forgetting and in leaving memory vulnerable to misleading information these findings may also have implications for questioning techniques employed by the police for the interviewing of eyewitnesses. The police typically rely on the standard interview and the cognitive interview for questioning witnesses but both of these methods are based on the repeated retrieval of information concerning a criminal episode. That is, the police typically ask the same, or very similar, questions repeatedly in order to determine the facts of a case. However, the current findings suggest that this questioning process may not only cause witnesses to forget potentially important details concerning an incident but also, in addition, leave those forgotten details vulnerable to being superseded by potentially misleading information. Additionally, as NRP-Similar items appear to be equally as susceptible to both inhibition and misleading information it suggests that the retrieval of seemingly unrelated information about a separate event can still result in retrieval-induced forgetting and misinformation effects.

CHAPTER 10

GENERAL DISCUSSION

One of the longest running, and controversial, debates in psychology concerns the issue of memory permanence. Of critical importance is whether information that is currently inaccessible in memory is permanently lost, or is all information encoded into long-term memory ultimately recoverable? Despite vigorous psychological research, using paradigms varying from retroactive interference and misinformation paradigms to thought suppression and directed forgetting paradigms, our understanding of how memory is updated remains limited.

The present thesis has focused on the misinformation effect, which has been used as a method for investigating how new or contradictory information updates older memories, thereby allowing questions concerning the fate of older memories to be investigated. While the effect in itself is a widely replicated finding within cognitive and applied psychology, there has been little agreement as to the underlying mechanisms. There has been much discussion as to whether the original memory remains intact, but that retrieval access is blocked in some way, or whether the original memory is corrupted in some way by the presentation of misinformation. To date, no mechanism has been put forward that can adequately explain how misinformation effects are produced.

The present thesis represents an attempt to apply recent research concerning inhibitory retrieval processes in forgetting to the study of the misinformation effect. The current findings suggest that inhibitory processes acting during retrieval may be at least one of the mechanisms that lead to misled participants reporting post-event misleading information in preference to the original information. This inhibitory

account of misinformation effects also allows for the interesting possibility of cross-category misinformation effects, which suggests that all information that is currently inhibited is susceptible to misleading information, irrespective of whether the original item occurred in the target event or not.

Experiment 1a suggests that retrieval-induced forgetting can be a critical boundary condition in the production of misinformation effects. The success of introducing misinformation appears to be determined by the type of item about which misinformation is introduced, with significant misinformation effects only to be found when misleading information is presented on items that have been subjected to retrieval-induced forgetting. Experiment 2a and 2b also suggest that retrieval-induced forgetting must be present at the time of introducing the misleading information. When retrieval-induced forgetting is absent due to its dissipation over a prolonged retention interval participants seem to be less likely to choose the misleading item at test than in conditions where retrieval-induced forgetting is evident. Experiment 3 examined the primary mechanisms underlying the retrieval-induced forgetting effect by using the independent probe method to test for inhibitory and non-inhibitory processes. Experiment 3 determined that retrieval-induced forgetting was still present when memory was tested using novel retrieval cues (i.e., 'independent probes'). Not only does the presence of retrieval-induced forgetting suggest that inhibitory processes are primarily responsible for retrieval-induced forgetting, but it also suggests that the memorial representations of the RP- items are genuinely inhibited. This important finding was replicated in both Experiments 4 and 5, and extended to include NRP items that were semantically similar to items from the practiced category. Specifically, the memorial representations of NRP items that were related to practiced RP+ items (i.e., cross-category effects) or inhibited RP- items (i.e.,

second-order effects) were also suppressed. The finding of inhibitory processes in retrieval-induced forgetting (Experiments 3 – 4), and cross-category/second-order impairment (Experiment 4) formed the basis of a further investigation into the role of inhibitory process in misinformation effects in Experiment 5. In this study, misinformation was found to have its greatest influence on memory when it was present on items that were inhibited (i.e., RP- and NRP-Similar items), but not on non-inhibited items (i.e., NRP-Dissimilar and Control items). This finding suggests that inhibitory processes may be at least one of the mechanisms influencing the misinformation effect.

Retrieval as a Memory Modifier

Unlike artificial memory storage systems, such as computers or compact discs, where the retrieval of stored information does not alter that information, the retrieval of information from human memory is thought to modify that system. It is a long established finding that the prior retrieval of information increases the probability of that item being successfully retrieved at a later date (e.g., Allen et al., 1969; R.A. Bjork, 1975; Carrier & Pashler, 1992; Koutstaal et al., 1998; Morris & Fritz, 2000, 2002), and the more difficult this initial retrieval is, the greater the benefit to subsequent recall attempts (Landauer & Bjork, 1978). Retrieval, however, not only strengthens those recalled items in memory; it can also modify the system by making other related items less available for retrieval. This form of forgetting associated with the retrieval of other related information is a property of human memory that has remained largely unexplored until recently when it has been identified as having a possible adaptive function in the maintenance of an efficient and flexible memory system.

To many people, forgetting is merely an irritating aspect of everyday life, and is seen as a wholly negative experience. However, it has recently been argued that forgetting is a necessary function in order to keep our memory system flexible and up-to-date (e.g., E.L. Bjork et al., in press; R.A. Bjork, 1989; M.D. MacLeod et al., 2003; Macrae & MacLeod, 1999). Previously stored out-of-date information could potentially disrupt the retrieval of desired memories if it is not forgotten in some way. Whether this forgetting consists of permanent erasure, or merely putting it aside in some way, it can provide a vital and adaptive function in memory preventing this unwanted information from competing for retrieval with target information and interfering with retrieval. Arguably, if we did not have a way of preventing redundant memories from vying for retrieval, we would likely fail to recall desired memories.

Despite such assertions that forgetting is an adaptive response to the goal-directed nature of our memories, and represents a way of controlling the contents of conscious memory, there may also be unintentional costs. While retrieval-induced forgetting has been explained as an adaptive feature of our memory systems in terms of current goals, it may not be consistent with the attainment of future goals. That is, while retrieval-induced forgetting can resolve competition at retrieval, resulting in the suppression of unwanted competitors, it may also prevent us from being able to recall one of those previously unwanted items at a later date. For example, in the retrieval practice paradigm, the RP- items are prevented from disrupting the selective retrieval of the target RP+ items, but retrieval-induced forgetting also prevents an individual from satisfying the future goal of reporting all of the study items during the final recall test. Current research has extended this finding to various social situations, discovering that the suppression of competing information may have negative consequences for interpersonal perceptions (M.D. MacLeod & Macrae, 2001; Macrae

& MacLeod, 1999), completing exams (Macrae & MacLeod, 1999), reporting a criminal event (M.D. MacLeod, 2002; Shaw et al., 1995), and the maintenance of stereotypical and individuating information (Dunn & Spellman, 2003). The current studies add to our understanding of the deleterious side-effects of an otherwise adaptive process in memory and, in particular, suggests that the unintentional forgetting of information may leave those items particularly susceptible to the effects of misleading post-event information.

Retrieval-induced Forgetting and the Role of Competition

The retrieval practice of the RP+ items has previously been identified as a necessary condition for retrieval-induced forgetting to occur (M.C. Anderson et al., 2000a) and, similarly in Experiments 1 – 5, participants were significantly better at recalling practiced items than either unrelated NRP items or control items. This suggests that retrieving an item from memory has a strong facilitatory effect on our ability to recall those items later. In contrast, as no relevant retrieval practice occurred in the control conditions of Experiments 1 – 5 there was no evidence of any facilitatory effects on memory performance. Similarly, no evidence was found of activation spreading from practiced items to unrelated NRP-Dissimilar items in Experiments 3 – 5.

The retrieval of a sub-set of items from a category not only had a direct effect on the subsequent reporting of those items (i.e., RP+), but it also directly affected the probability of related items being retrieved as well. The remaining items from the practiced category that were not themselves practiced (i.e., RP- items) were found to be recalled at a poorer level than other non-practiced items from unrelated categories (i.e., NRP-Dissimilar, control) throughout Experiments 1 – 5. This is despite the RP-, NRP-Dissimilar and control items all being unpracticed items. These three items only

differ in their degree of relatedness to the practiced items. While items from the NRP-Dissimilar category remain unrelated to the practiced items, and there are no practiced items in the control condition, the RP- items differ due to their episodic similarity to the RP+ items. That is, the RP- items appear in the same event as the practiced items. As the goal of retrieval practice was to retrieve only a sub-set of items, it may have been necessary for the RP- items to be prevented from attempting to compete for retrieval during this task. If the RP- items were allowed to compete for retrieval, they would have interfered with the goal of the retrieval practice task, and may have resulted in participants having difficulty in selectively retrieving the target RP+ items. As only the RP- items are similar to the target information, they are the only items that are likely to create interference, and thus, only the recall of these RP- items is selectively impaired.

Similarly, items in the unpracticed category that are semantically similar to items from the practiced category may also compete for retrieval and interfere with the selective retrieval of the target material (Experiments 4 – 5). These NRP-Similar to RP+ items are likely to compete directly with the RP+ items during retrieval practice. As these items are drawn from the same semantic category as the practiced item, they may be acting like a second RP- group, and thus suffer the same fate. However, this cross-category impairment is not just restricted to NRP items that are semantically related to practiced items, but also to NRP items that are related to RP- items as well. The impairment of these items is perhaps less intuitive given that the NRP-Similar to RP- items neither share a semantic link with the practiced item (although they do share an episodic link as both the practiced and unpracticed categories appeared within the same experiment). However, NRP-Similar to RP- items may be subjected to retrieval-induced forgetting because of their semantic

similarity with items that do compete with the RP+ items for retrieval (i.e., RP-items). This is discussed in more detail later in this chapter in terms of inhibitory processes.

Competition due to Similarity in the NRP Baseline Measure

Recall performance of the baseline NRP items was found to be impaired in Experiment 1 when it was compared to the control condition. This was likely to be due to the unintentional sharing of similarity between items across the two categories of items. While no significant cross-category inhibition was actually detected, this may have been due to the issue of nominal versus functional similarity (M.C. Anderson & Spellman, 1995). As a result, there may not have been enough related items to make any similarities salient, and thus participants will have failed to employ such relationships to aid or impair recall. However, there may have been sufficient competition for retrieval under some circumstance to lead to the retrieval-induced forgetting of some items, thus resulting in the depressed NRP performance.

In contrast, the possible contaminating effect of cross-category inhibition operating in the baseline NRP condition was controlled in Experiment 3. Items were specifically chosen that contained only weak relationships with each other, and these weak similarities were established through pilot work. Without the shared similarity between items these NRP items should not have competed for retrieval with the practiced items during the retrieval practice phase, and thus should not have been at risk of retrieval-induced forgetting.

The ability of this NRP category to act as a true unrelated unpracticed baseline measure was confirmed by participants' ability to recall these items at a similar level to that of the control items. This finding that memory for such unrelated items

remains unimpaired by the prior retrieval of practiced items was supported by the unimpaired recall of NRP-Dissimilar items in the final two studies. The recall performance for NRP-Dissimilar items in Experiments 4 – 5 was found to be of a similar level to that for control items. Therefore, items that are unrelated to either practiced items or inhibited items appear to be neither facilitated nor impaired by the retrieval of other items.

Does Inhibition Control the Spread of Activation?

The selective retrieval impairment of items that are similar to practiced items is perhaps surprising given the findings from studies using the DRM paradigm. This paradigm suggests that the prior study of items can lead to the spreading of activation from studied items to related but non-presented information (Roediger & McDermott, 1995), resulting in participants being more likely to mistake such similar 'lures' as having appeared in a previous list than dissimilar lures. However, if retrieval-induced forgetting is examined within this framework of spreading activation, it suggests that the selective impairment of RP- items may be a reaction to their prior activation. If the retrieval of RP+ items increases their retrieval strength in memory, then the activation of practiced items may spread to other items that are related either semantically (i.e., RP- and NRP-Similar items) or episodically (RP- items). Therefore, items semantically related to RP+ items that are either in the same practiced category or from a different unpracticed category could also be strengthened in memory. In addition, items that are in the same episode as the practiced items may also share in this facilitatory effect. However, as the retrieval practice task is goal-directed in the sense that it requires only a sub-set of items to be retrieved (in a time-constrained task as well), it would be inefficient for memory to allow all of these

related items to remain in a heightened state of activation. That is, these activated related items are likely to compete for retrieval with the RP+ items and therefore create a great deal of interference during the retrieval practice phase. Thus, retrieval-induced forgetting effects may be the result of a mechanism that dampens down the activation of these similar but unwanted items, thereby allowing the fast and efficient retrieval of desired memories.

Output Interference at Final Recall

Output interference was also dismissed as playing a primary role in the production of retrieval-induced forgetting effects. While output interference is an interesting phenomenon in itself, which can influence what information is retrieved and what remains unavailable for recollection, it is a process that operates only during the final retrieval of information. Thus, output interference can influence what information is recalled, but it is not a process that is triggered by the selective retrieval of information during the retrieval practice stage. As retrieval-induced forgetting is believed to be a result of retrieving only a sub-set of items it was vital that the effects of output interference are excluded as a possible explanation for these results.

Despite excluding output interference as a primary influence on the retrieval-induced forgetting effects found in Experiments 1 – 5, it should be noted that recent research provides preliminary evidence for inhibitory processes operating within output interference. Bäuml (1998) found that the prior recall of moderately strong exemplars in an output interference paradigm suppressed recall for strong items but not weak exemplars. This suggests that inhibition may not only be elicited during the retrieval practice of information, as implied by retrieval-induced forgetting (e.g., M.C. Anderson et al., 1994), but it may also be operating during the final recall phase.

The Inhibition of Competing Representations: I. Non-inhibitory Models

As both non-inhibitory strength-dependent competition models and inhibitory models can explain the basic 'retrieval-induced forgetting effect, it was necessary to identify areas where both models predict different patterns of results. It is vital that these distinctions are identified and explored as in many instances non-inhibitory models provide a more parsimonious explanation of retrieval-induced forgetting. Non-inhibitory and inhibitory models do differ on a number of predictions. Strength-dependent models assume that the strengthening of features is a non-specific process whereby memorial representations can be strengthened not just through retrieval, but also by simply presenting information. In contrast, inhibitory models specify that strengthening is specific to the retrieval process. Both models also differ in their predictions concerning the pre-experimental strength of memorial representations. Strength-dependent models do not consider the pre-experimental strength of representations so that the effects of strengthening on a pre-experimentally strong item should be the same as strengthening in a pre-experimentally weak item. On the other hand, inhibitory models do consider the pre-experimental strength of an item. Items that are considered strong members of a category should be subjected to a greater degree of inhibition than are items that are considered weak members of a category. Thus, strong items are assumed to create more competition and interference at retrieval than do weak members of a category.

A third difference between strength-dependent competition models and inhibitory models concerns predictions of cue-dependent and cue-independent forgetting. Strength-dependent competition models exclusively predict cue-dependent forgetting. That is, failure to recollect the target memory is due to changes in the association between the retrieval cue and the representation, such as through the use

of an inappropriate cue or associative blocking, thus preventing the trace being retrieved. This interference typically occurs because a competing item has been strengthened, resulting in the association between that retrieval cue and the related target item being weakened. However, if a new cue is used, and there is no interference occurring along the retrieval route between the cue and the memorial representation, then the memory should be successfully recollected. Thus, this type of interference is cue-dependent. In contrast, inhibitory models place the interference at the level of the memorial representation. Thus, it is the actual memorial representation that is inhibited in memory. This cue-independent forgetting continues to persist even when alternative cues and associative routes are used in a retrieval attempt.

Cue-independent forgetting is currently understood to be the strongest evidence for inhibitory processes in retrieval (M.C. Anderson & Bjork, 1994; M.C. Anderson & Spellman, 1995). At the core of strength-dependent competition models is the notion of cue-dependent retrieval and interference between traces that share the same retrieval cue. The remaining three studies (i.e., Experiments 3 – 5) attempted to establish whether cue-dependent or cue-independent forgetting was present in the retrieval-induced forgetting effect. This was investigated by using the independent probe technique whereby different retrieval cues were used at recall to the ones that were used during retrieval practice. By using novel cues in this way, it ensures that any strengthening between the RP+ items and the study cue does not affect the retrieval strength of any other item through processes such as blocking.

Although Experiments 1 and 2 did not set out to test any of these predictions, Experiment 3 established, according to M.C. Anderson and Spellman's (1995) criteria, that inhibitory processes were responsible for the observed retrieval-induced

forgetting effects. Even when the cues used to prompt recall differed from those used at both the study and retrieval practice phases, a pattern of retrieval-induced forgetting still emerged. As non-inhibitory theories of forgetting suggest that impaired RP- performance will only occur when RP- items share the same retrieval practice cue as the RP+ items (as it is the strengthening of the RP+ items association to the its cue through practice that blocks access to the RP- items), these theories would predict an absence of retrieval-induced forgetting when novel cues are used at recall. On the other hand, inhibitory theories of forgetting suggest that the activity of competing representations is actively reduced so that the target item can be retrieved. Therefore, as it is the actual item that is suppressed in memory, rather than it merely being blocked by the activity of a more highly activated representation, inhibitory theories would predict that the recall of competitors should still be impaired even when novel cues are used at test. As RP- recall performance was still impaired when novel retrieval cues were used (Experiments 3 – 5), the current set of results suggest that inhibitory processes represent the primary process governing the retrieval-induced forgetting effect in episodic memory. This suggests that non-inhibitory strength-dependent models of retrieval are insufficient (at least, as the primary process) to explain the presence of retrieval-induced forgetting using the independent probe method. In addition, retrieval-induced forgetting was not found in the control condition where participants engaged in a non-relevant practice task (Experiments 3 – 5). As this task was the only difference between the control and experimental condition, it strongly suggests that the inhibitory processes found in the experimental condition were elicited by retrieval practice. The inhibitory interpretation of Experiment 3 is further strengthened by evidence of retrieval-induced forgetting using the independent probe method in Experiments 4 and 5. Thus, the finding of inhibited

RP- items has been found in three separate experiments, and with changes in materials, suggesting a fairly robust inhibitory effect. In addition, Experiments 3 –5 currently represents the only set of studies other than those conducted by M.C. Anderson and colleagues (M.C. Anderson & Bell, 2001; M.C. Anderson & Green, 2001; M.C. Anderson et al., 2000b; M.C. Anderson & Spellman, 1995) to have found support for inhibitory process using the independent probe method.

The Inhibition of Competing Representations: II. Cross-category Inhibition

As M.C. Anderson and Spellman (1995) discovered that the likelihood of information being inhibited was dependent on its relatedness to items from practiced category, related sub-categories were introduced that spanned the two incidents in order to investigate cross-category effects. In Experiment 4, items from the unpracticed category (i.e., NRP items) were inhibited if they were semantically similar to practiced items (i.e., RP+), as well as if they were similar to inhibited items (i.e., RP-) from the practiced category. Inhibitory processes can be inferred as having been active because the recall of NRP-Similar items was impaired even though they were tested under a different cue to those cues used during the retrieval practice phase. Specifically, while NRP-Similar to RP+ items were tested using the same retrieval cue as the RP+ items (e.g., clothing), the RP+ items were studied and practiced under a different cue (e.g., Williams' House) to the NRP-Similar items (e.g., Thompson's House). As it is the strength of the association between the RP+ items and the retrieval practice cue that blocks retrieval of competing information in non-inhibitory theories of forgetting (e.g., Thompson's House – RP+ association), the use of shared novel cues at recall between the RP+ and NRP-Similar to RP+ items should still be sufficient to test the predictions put forward by inhibitory theories. Thus, the

impaired recall of NRP items that were similar to RP+ items suggests that these unpracticed but competing items are inhibited at retrieval, much like RP- items are. In fact, as these NRP-Similar items share a semantic category with the RP+ items, they may actually be acting like a second RP- group and are therefore competing directly with the practiced items for retrieval. In order to reduce the interference these similar items from the unpracticed category create during retrieval, they are inhibited in a similar fashion to the RP- items. This conclusion, that the NRP-Similar to RP+ items are acting in a similar way to the RP- items, is further supported by the finding that the difference in recall for the RP- and NRP-Similar to RP+ items was 5% or below (i.e., Experiment 4 – 5).

Similarly, in Experiments 4 – 5, the RP+ items were tested, as well as being studied and practiced, under a different cue to the NRP-Similar to RP- items. This was due to the NRP-Similar items in this condition sharing an implicit category with the RP- items, and thus being dissimilar to the RP+ items. Despite this change, the recall performance of NRP-Similar to RP- items remained impaired, even though these items did not compete directly for retrieval with the RP+ items. The presentation of items in the study phase is likely to raise the activation level of these items, and this activation may spread to all related information. The strengthening of associations between items that are semantically and episodically related may occur regardless of whether they were present in the study phase or not (as suggested by studies employing the Deese-Roediger-McDermott paradigm, e.g., Roediger & McDermott, 1995). An inhibitory process may provide a mechanism by which this activation can be counteracted and, therefore, prevent unwanted information cluttering up the retrieval of desired memories.

This activation during the study phase can potentially explain the inhibition of items from the unpracticed category that shares semantic features with the RP- items. If the association between RP- and related items is strengthened through their presentation in the study phase (e.g., leather jacket and trainers from the practiced house, sweater and jeans from the unpracticed house), then the inhibition of RP- items will also lead to the inhibition of related information (e.g., sweater and jeans). Therefore, it appears that when RP- items are inhibited, inhibition 'leaks' or 'spreads' from these items to any information that is related to. This means that items from the unpracticed category that are similar to the RP- items appear to suffer the same fate as their related RP- items. This pattern of impairment suggests that information that competes for retrieval with the target information, or that is similar to information that does compete, would create interference at retrieval and thus would be inhibited to allow for fast and accurate retrieval of the target material. In contrast, non-inhibitory strength-dependent competition models of interference cannot explain the impaired recall of NRP-Similar to RP- items. This type of NRP-Similar item does not share a retrieval cue with the target RP+ items and, therefore, cannot compete for retrieval with these items. Thus, as two of the assumptions of strength-dependent competition models have been violated, non-inhibitory theories would have predicted that recall of these items would not have been impaired. This additional exclusion of non-inhibitory theories as a possible alternative explanation of second-order impairment further strengthens the assertion that inhibitory processes are present in the current set of studies.

On the other hand, items from the unpracticed category that were semantically dissimilar to all items from the practiced category were unaffected by the prior retrieval of practiced items (Experiments 4 – 5). As these NRP-Dissimilar items are

not related to the practiced items, they do not share any facilitatory effects of activation spreading from the practiced items. Similarly, as these unrelated items are not activated by the retrieval of the target items, they are unlikely to compete for retrieval and therefore do not need to be inhibited in order to prevent them interfering with the retrieval of the RP+ items.

The current findings of impaired recall of RP- and both types of NRP-Similar items suggests that inhibition in retrieval-based theories of forgetting can be inferred in a mechanistic sense (as defined by R.A. Bjork, 1989). In the independent probe method, the "inhibition" of these competing items goes beyond the term's use in a theoretically neutral or weak descriptive sense. Thus, it is proposed that a mechanism is present that reduces the activation levels of competing representations which, in turn, allows for the quick and successful recollection of target memories. Such inhibitory processes would allow the human memory system to remain flexible and stable (Dagenbach & Carr, 1994) during the updating of memory. Therefore, the system would remain sufficiently modifiable through the temporary inhibition of competing representations, rather than the permanent erasure of information, allowing the system to be adaptable to changes in everyday memorial goals (M.D. MacLeod & Macrae, 2001; Macrae & MacLeod, 1999).

The only previous findings of inhibition in retrieval-induced forgetting has been by M.C. Anderson and Spellman (1995), who used lists of category exemplars, and Ciranni and Shimamura (1999), who used visuo-spatial materials, such as coloured shapes at different locations. Thus, these studies have employed very different materials to those reported in Experiments 3 – 5. The materials employed in these three experiments were episodically collected under arbitrary categories of "Thompson's House" and "Williams' House", rather than forming categories of

semantic or perceptually similar items. In addition, the target items appeared within a context (e.g., burglaries, houses), and appeared embedded within sentences, rather than being presented as word lists. The retrieval practice phase also differed significantly from that used by M.C. Anderson and Spellman and Ciranni and Shimamura. Rather than using a cue-plus-stem task, the retrieval practice task employed here consisted of repeated questioning that increased in difficulty with each proceeding set of questions. However, participants were explicitly informed which house they would be retrieving items from. Finally, the findings of retrieval-induced forgetting with the independent probe method using these materials suggests that inhibitory processes in retrieval can be examined in simpler stripped-down paradigms than that previously used by M.C. Anderson and Spellman. The number of target items used in the current set of experiments employing the independent probe method was approximately half that used by M.C. Anderson and Spellman, as well as the number of retrieval practice questions being greatly reduced. Therefore, much in the same way as Macrae and MacLeod (1999) demonstrated that the standard retrieval-induced forgetting paradigm could be simplified, the current experiments demonstrate that cue-independence can also be investigated using a more simplified paradigm.

The Inhibition of Competing Representations: III. The Role of Similarity in the Pattern Suppression Inhibition Model

The findings that NRP-Similar items also suffered from inhibition if they were semantically similar to items from the practiced category (Experiments 4 – 5) can be easily accommodated by the pattern suppression inhibition model (M.C. Anderson & Spellman, 1995). This model assumes that each item's memorial representation consists of semantic feature units that can be activated through the retrieval process or

can be inhibited through that same retrieval process. Thus, the retrieval of an item from memory will activate those features with that specific representation. In addition, if those activated semantic features appear in any other representation, then those features will also be activated. A similar pattern should occur for inhibited features. The retrieval of a representation will activate those features related to it and, in order to increase discrimination between that target trace and competing traces, those activated features within the competing memorial representations will be actively inhibited. Any other unwanted representation that shares these activated features will also be inhibited. Thus, a competing memorial representation can be facilitated through its similarity to the target trace, or conversely, it can also be suppressed due to its similarity. Whether a competing representation is inhibited or not will be dependent on the proportion of activated features compared to the proportion of inhibited features. If a competing trace is highly similar to the target representation, there will be a great deal of overlap between the features of the target and competing representations. This means that the number of shared activated features will be maximised and the competing trace should be greatly facilitated by the retrieval practice of the target representation (M.C. Anderson et al., 2000b; Bäuml & Hartinger, 2002). On the other hand, if the competing trace is similar to the target, but is not highly similar, then the number of overlapping features will be smaller. This means that the competing trace will share fewer activated features with the target representation. In order to increase discriminability between the target and competitor the features of the competing memorial representation are likely to be subjected to strong inhibition (Bäuml & Hartinger, 2002; R.E. Smith & Hunt, 2000).

The latter prediction of the pattern suppression model was upheld by the findings of Experiment 4 – 5. While members of the practiced category did share

similarities with members of the unpracticed category, each individual item within that shared category still retained several unique features. This is a vital factor when the NRP-Similar to RP+ condition is considered. In this condition, a sub-category of NRP items shares a category with a sub-set of RP+ items. Thus, sharing features with items that are facilitated through retrieval could also result in the recall of these NRP-Similar items being facilitated. However, unlike the materials used by M.C. Anderson et al. (2000b) and Bäuml and Hartinger (2002), individual items within the shared category contained several characteristics unique to each item, which were identified in pilot work. Further to this, if the net inhibitory, or facilitatory, effect is a result of the proportion of activated and inhibited features, then the fact that the NRP-Similar items were only moderately related should have resulted in the inhibition of those items. That is, the number of shared facilitated features was less than the number of unique inhibited features. This prediction, that moderately related competitors are subjected to inhibition, was confirmed.

It does remain possible that these semantically dissimilar NRP items are affected by the inhibited NRP items in their episodic category, and that this effect is not strong enough to be measured by recall. This possibility is dependent on whether inhibition is an 'all-or-nothing' effect, or occurs in increments. If inhibition is either 'on' or 'off' then perhaps dissimilar NRP items remain unaffected by the inhibited members of its episodic category. However, if inhibition occurs on a continuum, from 'slightly inhibited' to 'completely inhibited' then it remains possible that the NRP-Dissimilar items are affected by the inhibited NRP-Similar items. For example, inhibition from the NRP-Similar items could 'leak' across to the NRP-Dissimilar item, simply because they share an episodic category, in a similar manner to that of the 'leaking' of inhibition from RP- items to NRP-Similar items. Unfortunately, if

this inhibition is fairly weak, a cued-recall task may be insufficiently sensitive to measure it. Other measures, such as reaction times, have previously been advanced as a more sensitive measure of memory (E.F. Loftus et al., 1989). Thus, while NRP-Dissimilar items may appear not to suffer any inhibition, as measured by cued-recall, there may be a slowing down of retrieval access. Comparing retrieval speed between the various types of items may reveal some very interesting findings. As RP+ items have been strengthened through practice, retrieval speed of these items on a cued-recall test would be expected to be quick. In contrast, as the RP- and NRP-Similar items have been strongly inhibited in memory, participants are not expected to be able to retrieve these items at all. However, RP- and NRP-Similar items that are more weakly inhibited may be eventually retrievable, but with great effort. For these items, retrieval speeds are expected to be very slow. Control items, for which no practice has occurred on any of these items, is expected to be relatively fast and easy, though not as fast as for RP+ items, as control items have not benefited from strengthening through prior retrieval. Finally, if some inhibition has leaked from the NRP-Similar items to the NRP-Dissimilar items, then retrieval speeds can be expected to be slower than for control items, though not as slow as for the strongly inhibited RP- and NRP-Similar items. However, if there are weakly inhibited RP- and NRP-Similar items that were eventually recalled, then retrieval speed for NRP-Dissimilar items may be of a similar speed to these items. Unfortunately, while this would be interesting to investigate, if NRP-Dissimilar impairment was found it could be argued that it was not due to inhibition leaking to episodically related items, but is in fact due to a poor choice of materials. That is, extensive piloting would have to be undertaken in order to prevent unknown semantic associations between NRP items obscuring the results.

Retrieval Status: I. Retrieval-induced Forgetting as a Boundary Condition to the Misinformation Effect

Experiment 1a demonstrated that misinformation effects were largest when misleading information was presented on items that were subjected to retrieval-induced forgetting, such as RP- items. In contrast, very few participants chose the misleading item when it had been introduced on an item that was not subjected to retrieval-induced forgetting. This non-significant effect of post-event misleading information was found irrespective of whether the misinformation was introduced on a practiced item, or on an item from the unrelated unpracticed category, or on a control item where no relevant retrieval practice had occurred, and was unlikely to be due to a lack of power (χ^2 values were extremely low in these conditions). This difference in the magnitude of the misinformation effect based on the retrieval status of the original item suggests that misinformation has its greatest impact on performance on the recognition test when the original item was unavailable to conscious inspection (e.g., Experiment 1a: 60% of participants chose the misinformation item in the MisRP- condition). When the original item cannot be brought into consciousness, participants are more likely to choose the misleading item, which is available for retrieval. On the other hand, if the original item can be brought forth into conscious awareness, then participants appear to be more likely to choose that item over the misinformation (e.g., Experiment 1a: 20% of participants chose the misinformation item in the MisNRP condition).

That the retrieval availability of the original item is critical to the misinformation effect is further supported by the observation that participants in the MisRP- condition who demonstrate retrieval-induced forgetting are far more likely to choose the misleading item than are participants who do not demonstrate retrieval-

induced forgetting. Taking these findings together suggests that misinformation must be introduced on an item that is not only subjected to retrieval-induced forgetting, such as RP- items, but also that participants are themselves demonstrating a significant retrieval-induced forgetting effect. The possibility of retrieval-induced forgetting being a boundary condition in the production of misinformation effects was further investigated in Experiment 2b through the manipulation of a delay. As retrieval-induced forgetting has been found to be a temporary forgetting effect that dissipates over time (Experiment 2a of the current thesis; M.D. MacLeod & Macrae, 2001), the possibility that it is an essential condition for the successful introduction of misinformation can be investigated. In support of the conclusions of Experiment 1a, misinformation only had a significant effect on memory when retrieval-induced forgetting was still present during the experimental session. In contrast, when retrieval-induced forgetting had dissipated over a 24-hour delay, the level of misinformation effects were comparable to that of Experiment 1a where misinformation was introduced on items not subjected to retrieval-induced forgetting (i.e., RP+, NRP, or control items).

Retrieval Status: II. Introducing Misinformation on Inhibited Items

The presence of retrieval-induced forgetting and the retrieval status of an original item (i.e., Experiment 1a and 2b) may be strong predictors of misinformation effects but, on their own tell, us little about the specific mechanisms underlying the misinformation effect. However, by employing the independent probe method (i.e., Experiment 5), the level at which inhibition operates, as well as the type of mechanisms present, can be examined. As the independent probe method confirmed that the RP- items were inhibited, as well as the NRP items that were semantically

related to either the practiced RP+ items or the inhibited RP- items, the impact of introducing misinformation on these inhibited memorial representations could be examined. As expected, misinformation was observed to have its greatest impact when presented on inhibited items. Fifty-seven percent of participants were found to choose the misinformation item when misleading information was presented on an RP- item, which is comparable to that found in Experiments 1a and 2b. Interestingly, when misinformation is introduced on items from the unpracticed category that are semantically related to items from the practiced category, the magnitude of the misinformation effect is of a similar size. When misinformation is introduced on NRP items that share a semantic category with the practiced items, 47% of participants chose the misinformation item, while 67% of participants chose the misinformation when the NRP item is semantically related to an inhibited RP- item. While this latter misinformation effect is slightly larger than that typically found on RP- items (and on NRP-Similar to RP+ items), this difference was not significant. Similarly, the difference between the size of the misinformation effects for NRP-Similar to RP+ and NRP-Similar to RP- items was not significant. Thus, it appears that both NRP-Similar to RP+ and NRP-Similar to RP- items have a similar degree of susceptibility to the introduction of misinformation as the RP- items are. Thus, due to their inhibitory status, these items are also susceptible to misinformation, despite not having appeared in the target event. This conclusion was further supported by the finding that misinformation had its greatest effect when participants demonstrated retrieval-induced forgetting (i.e., inhibition) and the misinformation was presented on an inhibited item. That is, each condition can be divided into those participants who demonstrate retrieval-induced forgetting and those who do not. Those participants who received misinformation on an inhibited item and who showed evidence of

retrieval-induced forgetting were 2 – 7 times more likely to choose the misinformation at test than participants who received misinformation on an inhibited item but who failed to demonstrate retrieval-induced forgetting. Further to this, the proportion of misinformation effects found in the inhibited conditions of Experiments 1a, 2b, and Experiment 5 were of similar magnitude.

Retrieval Status: III. Impaired Performance or Inhibited Representations?

As the independent probe method confirmed that inhibitory processes were present in Experiment 5 it can allow for conclusions to be drawn concerning the memorial representations of the original items after the presentation of misleading information. Perhaps most importantly, the findings of Experiment 5 suggest that the misinformation effect not only represents a change in performance but, critically, it also represents a change in the availability of the underlying memorial representations. Not only does presenting misleading information in each condition help to control demand and social factors (which would otherwise suggest that participants choose misinformation even though the original item was freely available for retrieval), but the employment of the independent probe method strongly suggests that the memorial representation of the RP- items, and the NRP-Similar items, have been actively (and specifically) suppressed. Therefore, the finding that the success of introducing misinformation is dependent on the inhibitory status of the original item that is targeted by the misleading information suggests that previous criticisms that the misinformation effect does not represent true memory impairment (e.g., McCloskey & Zaragoza, 1985a), or that it fails to correspond to a change in the underlying memorial representations (e.g., Schooler & Tanaka, 1991) do not, in this case, appear to be justified. The use of the independent probe method provides strong

evidence that participants who demonstrate inhibition truly have 'impaired memory' (Belli, 1989), or a 'change in memorial representation' (Schooler & Tanaka, 1991) for the events contained within the study phase.

Retrieval Status: IV. Introducing Misinformation on Non-inhibited Items

Using the independent probe method in Experiment 5 also allowed for the retrieval status RP+, NRP-Dissimilar and control items to be confirmed. Although these items differed as to whether they had been previously retrieved (i.e., RP+ items) or not (i.e., NRP-Dissimilar and control items), all of these items were confirmed as not presently being the focus of inhibition. Significant misinformation effects were not detected in these conditions, and in the case of the NRP-Dissimilar items, this was regardless of whether retrieval-induced forgetting was present or not. Similarly, the proportion of misinformation effects for RP+ items (16%) in Experiment 1a is comparable with that for NRP-Dissimilar items (23%) and control items (17%) in Experiment 5, with very little difference in the size of the observed misinformation effect. This is despite the RP+ items having been strengthened in memory through retrieval practice. Thus, it would seem that additional retrieval, while strengthening the item in memory, does not really garner any extra resistance to misleading information compared to unpracticed, but non-inhibited, items. These latter points further support the notion that not all items in an event are susceptible to misinformation but that only inhibited items are indeed vulnerable.

The differences in retrieval-induced forgetting and misinformation effects between the RP- and NRP-Similar items, and the NRP-Dissimilar and control items, are of interest given that all four of these item types are all non-retrieved items that only differ in their relation to information that has previously been retrieved. Due to

these items all being non-retrieved, they adequately demonstrate how retrieval can act as a memory modifier in two distinct ways (i.e., it may both increase and decrease the retrieval availability of information in memory) that may promote the updating of our memory systems, as well as regulating what material is available to conscious awareness at any given time.

Addressing the Issue of Memory Permanence: I. Alteration or Coexistence of Memories

The current studies also address the debate concerning the permanency of memory. Previous research investigating retrieval-induced forgetting, retroactive interference and misinformation effects have attempted to address this most fundamental of questions within cognitive psychology. The current set of findings strongly suggests that once information has been encoded into long-term memory, it resides there (for all intent and purpose) permanently. In Experiment 2, the impaired recall of RP-items was found to be temporary, with retrieval-induced forgetting dissipating over the course of a 24-hour delay. The idea of retrieval-induced forgetting as a temporary forgetting mechanism is strengthened by prior research demonstrating a slight recovery in participants reporting RP-items over the course of a delay (M.D. MacLeod & Macrae, 2001). However, a similar recovery in RP-performance was not found in Experiment 2, but this could have been due to reasons consistent with the arguments put forward by M.D. MacLeod and Macrae (2001). Perhaps retrieval-induced forgetting (and inhibition) is an 'on/off' process, whereby it is either present or absent, or is a graded process that accumulates and dissipates in increments. The latter type of process seems most probable given that M.D. MacLeod and Macrae and found only a slight recovery in the recollection of RP-items, and no such recovery

was actually observed in Experiment 2. This then raises the further possibility that if a longer delay was employed in Experiment 2, then a full recovery in RP-performance (i.e., to a level comparable with that of the other unpracticed NRP items) may have been observed. Of course, given its proposed role as an adaptive forgetting mechanism, retrieval-induced forgetting is unlikely to be bound by a '24-hour rule' whereby it is always found to dissipate over this time period. In fact, under some circumstances it may be more adaptive to suppress unwanted memories for longer periods, or even permanently (M.C. Anderson, 2001; M.D. MacLeod et al., 2003).

While retrieval-induced forgetting is one method of examining questions that concern memory permanence, the manipulation of retrieval status within the misinformation effect provided an alternative way of addressing these questions. The findings of Experiments 1a, 2b, and Experiment 5 not only support the notion of the original trace coexisting after the encoding of the misleading item, but that misinformation effects can be controlled through the manipulation of the retrieval status of the original item. If the encoding of the post-event misleading information erased the original trace, as proposed by the alteration hypothesis, then a similar level of misinformation effects should have been observed across conditions. However, significant misinformation effects were only found when misleading information was presented on inhibited items. This finding also fails to support the alteration hypothesis' proposal that the destruction of the original trace through the encoding of the misinformation item is a relatively quick and fairly automatic process that is only circumvented though strengthening an individual's resistance to misinformation prior to its encoding (e.g., E.F. Loftus, 1979b; Tousignant et al., 1986).

The finding that the inhibition of the original item is a strong predictor of how successful the introduction of misinformation will be further suggests that retrieval

failures may be implicated in the production of misinformation effects. This finding is consistent with the coexistence hypothesis, which not only assumes that the original item can continue to reside in memory after the encoding of the misleading item, but also that retrieval failures are the primary cause of misinformation effects. In the current studies (especially Experiment 5), significant misinformation effects were primarily observed where retrieval failures (i.e., inhibition) were present, which was seen mainly with competing items such as RP- items and NRP-Similar items. In contrast, items that were not subjected to significant retrieval failures, such as the RP+, NRP-Dissimilar and control items, were fairly resistant to misleading information, with these items being successfully reported the majority of the time. The strong retrieval component that appears to be present in misinformation effects can also be interpreted as further evidence against the alteration hypothesis.

Addressing the Issue of Memory Permanence: II. Level at which Retrieval Impairment Occurs

While the findings of Experiments 1a, 2b and Experiment 5 support the assumption of the coexistence hypothesis (that the original item and the misleading item coexist in memory) this does not itself inform us of where in the retrieval process such retrieval failures occur. That is, the interference could occur at the level of the retrieval cue, the retrieval route, or at the level of the memorial representation. Prior retrieval accounts of misinformation effects have typically explained the effect as being due to the use of inappropriate retrieval cues and retrieval routes. This makes the encoding specificity hypothesis (e.g., Bekerian & Bowers, 1983), cue-change (Chandler & Gargano, 1995; Chandler et al., 2001), and blocking and discrimination (Chandler & Gargano, 1998; Chandler et al., 2001), all examples of cue-dependent forgetting and,

therefore, non-inhibitory accounts of misinformation effects. This means that previous retrieval interference accounts have never implicated the role of inhibitory processes, or placing the interference at the level of the memorial representation, when attempting to explain why these types of memory errors occur.

The difference between non-inhibitory and inhibitory accounts of misinformation effects is most apparent when techniques that target the original item for retrieval are considered. Some non-inhibitory theories, such as cue-change and blocking, assume that the reason that the misinformation item is reported is due to it being encountered after the original item and therefore closer to the recognition test. As the misinformation was encoded closer in time to this test, the retrieval route from the cues present at test to the misinformation trace are stronger than the retrieval route running from those cues to the original trace. As a result, the accessing of the misinformation trace through this strengthened retrieval route prevents the original trace from being specifically accessed by its own unique cue, either through a blocking or discrimination process (Chandler & Gargano, 1998), or through the misinformation altering the properties of the retrieval cue (i.e., cue-change, Chandler & Gargano, 1995). These explanations would therefore suggest that this strengthening of the retrieval route between the cue and the misinformation item, and the changing of the properties of the retrieval cue by the misleading item, can be overcome by increasing the length of time between presenting of misinformation and final test. This is due to retrieval changes being fairly transitory and, in the case of a blocking process, the strength of the retrieval route to the misleading item will decrease over time. However, employing retrieval cues that will either specifically activate the original trace, or that will activate the original trace before it activates the

misinformation trace, should also prove a successful method in recovering the original item.

With cue-change, the assimilation of features from the misinformation trace on to the retrieval cue will be a better match to the misleading items, but only while those features remain activated. After a prolonged delay these features will become deactivated making it less of a match to the misleading item. Similarly, cue-change predicts that the probability of either the original item or the misinformation item being recalled is dependent on how many activated features of the cue match each trace. Therefore, employing retrieval cues that share more features with the original trace than with the misinformation trace increases the likelihood of the original trace being specifically activated.

The encoding specificity account of misinformation effects provides a similar account proposing that the cues that are present during the recognition test are a better match to the misinformation item than to the original item. This is primarily due to the misinformation item being encoded closer to the test than the original item resulting in the retrieval route between the cues at test and the trace of the misleading item being stronger than that for the original item. Thus, in a similar manner to the previous retrieval accounts proposed by Chandler and colleagues (e.g., Chandler & Gargano, 1995, 1998), employing retrieval cues that are a better match to the original trace, or that uniquely activate that trace, should see the original item being reported without interference from the misleading item.

All of these non-inhibitory accounts assume that retrieval interference occurs before the memorial representation, which means that any retrieval route used that is free from interference should result in the successful retrieval of the original item. In contrast, as inhibitory theories assume that the memorial representation of the original

item is specifically inhibited, this means that employing new retrieval cues and retrieval routes that are free from interference should fail to see the original trace being accessed and retrieved. This may mean that the original item will remain suppressed irrespective of the quality and quantity of the retrieval cues employed. Even if a retrieval cue is used that would only access the original trace, it will still not result in the retrieval of that item. In this sense, the failure to find a successful retrieval method within the framework of the inhibitory account is similar to that of the alteration hypothesis, which also suggests that retrieval techniques would always fail to access the original item. However, while the alteration hypothesis proposes that the only way to recover the original item is to re-encode that item, the only successful technique that sees the original information again becoming available in memory thus far, where an inhibitory mechanism has been implicated, is time (M.D. MacLeod & Macrae, 2001).

Thus, it would appear that an inhibitory account of misinformation effects has some properties in common with the coexistence hypothesis, and more surprisingly, with the alteration hypothesis. However, the inhibitory account has several critical differences with both the alteration and coexistence hypotheses, suggesting that perhaps interpreting the current results within these previous explanations of misinformation effects may be inappropriate. In fact, the inhibitory account may actually have more in common with McCloskey and Zaragoza's (1985a) non-retention explanation of misinformation effects. The non-retention hypothesis assumes that memory for an event can only be modified if the original item is not available in memory, thus suggesting that misinformation effects are due to issues with the memorial representation of the original item. This general assumption is quite similar to that of the inhibitory account, which suggests that misinformation can

only be successfully introduced on an item when it is unavailable to conscious inspection. In contrast, when the original item is freely available for retrieval, very few participants choose the misleading item. Thus, in this way, the inhibitory account's assumption that memory for an event can only be manipulated by misleading information when the original trace is unavailable in memory is very similar to that of the non-retention account's assumption that the original trace is not present in memory. However, both accounts differ concerning the reasons why the original trace is absent from conscious awareness at the time of the recognition test. While the non-retention account assumes that the original item was never encoded in the first place, suggesting that the misinformation effect does not represent true memory impairment, the inhibitory account assumes that the original item is not available to conscious inspection because of the actions of inhibitory processes, rather than any failure to encode (Experiment 1b). Thus, the inhibitory account strongly suggests that the misinformation effect is the result of genuine memory impairment.

Non-inhibitory Processes in Retrieval-induced Forgetting and Misinformation Effects

It should also be noted that inhibitory processes are unlikely to be triggered under every situation in which only a sub-set of items is retrieved, and inhibitory processes will not underlie every individual who demonstrates a retrieval-induced forgetting effect. For example, M.D. MacLeod (2003) has found that older adults can demonstrate a strong retrieval-induced forgetting effect, but that this effect is primarily due to output interference acting at the retrieval stage, rather than inhibitory processes elicited at the retrieval practice stage. A possible role for non-inhibitory processes in retrieval-induced forgetting can also be seen in studies by Shaw et al. (1995), where output interference may have influenced the pattern of recall, and

studies by various other researchers who have failed to discount non-inhibitory processes, either through controlling output order or by calculating their impact statistically post-hoc (e.g., Moulin et al., 2002; Williams & Zacks, 2001). It should however be noted that, under certain circumstances, output interference could also be the result of inhibitory processes acting at the final recall stage (Bäuml, 1998). Thus, Belli's (1989) conclusion that there can be multiple routes to misinformation effects may also apply to the production of retrieval-induced forgetting effects.

The Role of Demand Characteristics

One of the primary criticisms against the typical misinformation paradigm has been the contamination of the misinformation effect by demand characteristics inherent in the typical misinformation procedure (McCloskey & Zaragoza, 1985a). In the typical misinformation paradigm, misled participants may report misleading information in accordance with their belief that the experimenter wishes them to, rather than because they genuinely believe that the misleading item originates from the target event. Such demand characteristics can influence the misinformation effect when the post-event misleading item occurs only in a sub-set of conditions. This situation arises in the majority of misinformation studies due to the misinformation effect typically being measured by comparing the reporting of the original item by misled participants to that of control participants who have only received consistent post-event information. However, the possibility of misinformation effects arising through differences in demand characteristics across conditions has been removed in the modified misinformation paradigm employed in Experiments 1a, 2b and Experiment 5. By introducing post-event misleading information in every condition, the misinformation

effect is measured by comparing the reporting of misinformation in conditions where misleading information has previously been encountered.

Demand characteristics can also contribute more specifically to the misinformation effect when participants in the misled condition remember both the original item and the misinformation item. When participants remember both items they may report the misleading item because they believe that the experimenter composed the post-event questions or narratives and must therefore know what was present in the original target event. This bias is typically absent from the control condition of misinformation studies (e.g. E.F. Loftus et al., 1978) as only consistent post-event information has been presented, and thus participants are unlikely to choose the misleading item for this reason. In this case, the misinformation effect is not measuring whether the misleading item has been integrated into memory for the target event, but instead is measuring a bias towards choosing the misinformation. There remains the possibility that this bias towards reporting the misleading item could be present in the modified misinformation paradigm described within the present thesis (Experiments 1a, 2b and 5) although it is unlikely to be equal over conditions and most likely to be present in conditions where both the original item and the misleading item are available for retrieval. The probability of participants recollecting both of these items is most likely to occur where misleading information is introduced on the non-inhibited RP+, NRP-Dissimilar, and control items. It is in these conditions that participants are most likely to recall both the original and the misinformation item due to the original item not being subjected to inhibition. Thus, a bias towards choosing the misleading item in conditions where misinformation is introduced on non-inhibited items cannot be discounted. However, this does not really create problems for the inhibitory account of the misinformation effect as a bias

towards reporting misleading information is reduced in conditions where misinformation is presented on inhibited items (i.e., RP- and NRP-Similar). Under such inhibitory conditions, participants are unlikely to be able to bring the original item readily into consciousness. Thus, participants are more likely to choose the misinformation item as it is available in memory, and not because participants have to choose between items that they remember.

Applying Retrieval-induced Forgetting to Real-world and other Psychological Phenomenon

This research has obvious implications for any situation where only a sub-set of items is reviewed. While the current findings suggest that inhibitory processes play a strong role, thus suggesting that any task that requires only a sub-set of items to be *retrieved* can elicit this type of forgetting, the results could have also been the product of non-inhibitory processes. As retrieval-induced forgetting can also be explained by the actions of non-inhibitory processes, strengthening one retrieval route at the expense of related routes, this would imply that tasks that require only a selective *review* of information may also elicit retrieval-induced forgetting (e.g., extra study time, presentation of information). The type of tasks that have this minimal retrieval component could be tasks such as reading of a witness' statement, or a newspaper article about a crime, or having trial statements read back during jury deliberation, and may be sufficient to elicit non-inhibitory processes.

This research not only has applications to real-world memory problems, but also other psychological phenomenon. Retrieval-induced forgetting has obvious applications to both the verbal overshadowing effect (Schooler & Engstler-Schooler, 1990), whereby describing a face impairs ability to later recognise that same face, and

the imagination inflation effect (Garry, Manning, Loftus & Sherman, 1996), whereby imagining untrue life events increases confidence that it is a real memory at a later date. Both of these types of memory impairment are triggered by memory tasks that have a high retrieval component to them, a component that has been largely ignored. In addition, the underlying memorial mechanisms have also been largely ignored in favour of researchers investigating the boundary conditions of these effects.

The underlying mechanisms of verbal overshadowing remain relatively ignored, with only recent interest in a possible processing shift elicited by the descriptor task. It has been suggested that the verbal descriptor task encourages individuals to engage in more feature-based processing, while the recognition task requires individuals to engage in the more appropriate holistic processing that would normally be used in face recognition (Macrae & Lewis, 2002). However, Meissner and colleagues have recently suggested that retrieval processes may influence the verbal overshadowing effect (e.g., Meissner & Brigham, 2001; Meissner, Brigham & Kelley, 2001).

There are some features of the verbal overshadowing effect that easily fit into a retrieval-induced forgetting framework. Most critically, the descriptor task that requires participants to describe a face can not only be conceived as a retrieval task, but also as an incomplete retrieval task. This is due to participants being unable to adequately re-interpret complex visual information into words and so a great deal of vital information remains unretrieved. Further to this, verbally describing this type of visual information could also be argued to be a very difficult retrieval task. As difficult retrievals are thought to have the greatest impact on memory (R.A. Bjork & Bjork, 1992; Landauer & Bjork, 1978), the verbal descriptor task may set up the conditions necessary to produce retrieval-induced forgetting – in a similar way to

post-event questioning in the misinformation paradigm. These notions are supported by the finding that the standard interview and the cognitive interview, that are both based on the repeated retrieval of the same information, both elicit verbal overshadowing effects (Finger & Pezdek, 1999). In addition, the verbal overshadowing effect has been found to disappear when a two-day delay occurs after the descriptor task, a finding consistent with the temporal boundary of retrieval-induced forgetting (Experiment 2 of the present thesis; M.D. MacLeod & Macrae, 2001). Further to this, if describing a face results in the suppression of non-retrieved facial information, this information could be left vulnerable to any incorrect information encountered after the event. The assimilation of this incorrect information into an individual's memory for that suspect's face could result not only in the construction of a misleading photograph but also in the assembly of live line-ups and photographic line-ups.

Inhibitory retrieval processes may also play a role in the imagination inflation effect. Garry et al. (1996) originally suggested that the increased confidence that an untrue memory had actually happened after imagining that untrue event may be due to several possibilities, such as source misattribution error, hypermnesia, familiarity effects, repeated exposure to the materials, or a combination of all of them. However, the mechanisms that could produce these effects remain unknown (Garry & Polaschek, 2000), and a strong role for retrieval process has yet to be implicated. But, as the imagination task requires participants to generate information consistent with the suggested event, it may strengthen the imagined event in memory and result in the suppression of information that may help an individual detect that the memory is false. This possibility is strengthened by recent finding that semantic generation (Bäuml, 2002) can elicit retrieval-induced forgetting.

Implications for Questioning Techniques

For many years, researchers have been interested in investigating memory processes in order to better understand and improve eyewitnesses' ability to recall events. As an eyewitness can portray an understandable and human element of a crime, their statement can be central to the prosecution's case. It is crucial, therefore, that an eyewitness account is as accurate and as complete as possible. Memory researchers hope that the study and understanding of retrieval and storage processes will allow a certain degree of control to be exerted over a witness' retelling of an event.

The potential deleterious effects of retrieval-induced forgetting on eyewitness memory has been studied and discussed by previous researchers (Shaw et al., 1995; M.D. MacLeod, 2002). Eyewitnesses are subjected to repeated questioning by police interviewers in an effort to gain as complete and as accurate a report as possible, as well as retelling the event to friends and family. Shaw et al. (1995) suggested that this questioning could be considered an incomplete retrieval task much like retrieval practice. This questioning, as Shaw et al. points out is more than "a simple matter of taking a reading on the witness's memory" (p.249). Both Shaw et al. and M.D. MacLeod have demonstrated that items that are questioned in an eyewitness paradigm are better recalled than items from non-questioned categories. In addition, the current findings demonstrate that these practiced items are fairly resistant to misinformation. Unfortunately, items related to these questioned items but are not themselves asked about, appear to be impaired by this interrogation process (i.e., RP- items). In addition, these impaired items are very susceptible to the effects of misinformation. This is a double blow for the reliability and accuracy of an eyewitness' statement as these results suggest that not only may the questioning process employed by police

interviewers lead to impaired recall in itself, but it also leaves inhibited items open to being replaced by incorrect information.

In recent years, the cognitive interview has been advanced as an alternative questioning technique that has been shown to increase the average number of correct facts retrieved about an incident by about 25-35% compared to the standard interview (Geiselman & Fisher, 1997). In addition, the cognitive interview has been shown to reduce the number of incorrect responses (Geiselman & Fisher, 1997), although this is not always the case (e.g., Fisher, Geiselman, Raymond, Jurkevich & Warhaftig, 1987). Despite the perceived superiority of the cognitive interview, it may be as susceptible to retrieval-induced forgetting and, therefore misinformation effects, as the standard interview. The cognitive interview is based on the assumptions of the encoding specificity hypothesis, and therefore assumes that the retrieval of information about an event is cue-dependent. By using techniques such as context reinstatement (e.g., environmental and internal information), as well as encouraging witnesses to report information in different temporal orders and perspectives, it is assumed that these methods will provide multiple retrieval cues to information stored in memory. Even if some of the cues prove to be ineffective, encoding specificity would predict that the information will be retrievable given the employment of the correct retrieval cues. However, if details from that event were subjected to inhibition triggered by the incomplete retrieval of information, then the use of such multiple cues would still fail to see the desired information being retrieved. These inhibited items in the cognitive interview could also be just as susceptible to misleading post-event information as information may be in the standard interview. In fact, after some of those details have been suppressed, questions that encourage witnesses to report event details from different perspectives, or from different temporal orders, may

unintentionally lead to the confabulation of details in order to fill in the 'missing' parts of an individual's memory. The possibility gains credence from Meissner et al.'s (2001) finding that forcing an individual to complete a description of a face can lead to the self-generation of misinformation in order to fill in gaps in the memory report.

The current findings add to other researchers' prior conclusions that the incomplete questioning of witnesses can result in the impaired recall of some details of an event, in addition to leaving those details susceptible to misleading information. While techniques such as the cognitive interview would suggest that memory impairment can be overcome through the employment of multiple retrieval cues, the inhibitory account of retrieval failures would suggest that this technique is unlikely to be successful. This creates some problems for questioning techniques as reversing the inhibitory status of information has proven difficult, with the length of the retention interval after retrieval being the only successful method discovered so far for overcoming suppression (M.D. MacLeod & Macrae, 2001). Even re-presenting items during a recognition test has failed to reverse the retrieval-induced forgetting effect (M.C. Anderson et al., 1997; Hicks & Starns, in press). Thus, the only way to overcome the inhibition of event details would be to question witnesses in more than one interview session, with a considerable delay between sessions.

Despite these issues with *overcoming* inhibition there is some evidence to suggest that there may be methods that can prevent inhibition from being *triggered*. Research examining the effects of integration on memory suggests that integrating RP+ and RP- items can protect memory from inhibition (M.C. Anderson et al., 2000b; Bäuml & Hartinger, 2002). Specifically, encoding explicit links between target items and their competitors may prevent retrieval-induced forgetting from being triggered.

Thus, it may be possible to design questioning techniques based on the idea of integration as a way of protecting witnesses' memory for an event from inhibition (and, therefore, misinformation).

Conclusions

The current thesis represents an attempt to apply recent research to an old debate concerning memory updating: the role of inhibitory processes in the misinformation effect. While the misinformation effect is typically viewed as a method for examining memory updating, very little research has actually focused on the underlying processes in memory. Therefore, the construction of a novel misinformation paradigm, and the five experiments included herein, provide an initial step towards understanding the mechanisms underlying the misinformation effect, and memory updating in general.

Recently, researchers have suggested that forgetting may be a requirement of memory in order for current memorial goals to be satisfied. Without this ability to forget unwanted or out-of-date information, it may interfere with attempts to retrieve desired memories, leading to a slow and highly inefficient retrieval system, as well as an inflexible memory updating process. Inhibitory processes may provide a mechanism by which unwanted information is set aside, thus preventing it from interfering with current goals. Similarly, the inhibition of out-of-date or contradictory information can allow for memory updating to occur with relative ease. As older information will be unavailable to conscious inspection, newer information can more easily be integrated into memory.

However, the current research suggests that memory updating through the inhibition of older or unwanted information may not always have desirable outcomes

and, thus, there may be negative consequences to an otherwise adaptive process. The current research suggests that when information has been inhibited, contradictory information is easily integrated into event memory and is reported in place of the correct information. This altering of memory for an event has obvious negative consequences, especially for circumstances where the veracity of our memories is imperative, such as eyewitness memory. However, the vulnerable position of inhibited memories in the face of conflicting information need not be of over-riding concern to those groups that rely on the accuracy of memory. Inhibition appears to be a fairly transitory process that dissipates over time, although this area of research requires a great deal of further research to determine those conditions that promote this dissipation, as well as identifying those conditions that promote the maintenance of inhibition.

CHAPTER 11: REFERENCES

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APPENDIX A

Stimuli used in Experiment 1a

Appendix A1

Study Phase: Narratives

Jones' House

The Jones' house was burgled at the New Year. Mr. and Mrs. Jones were out at an office party, while their children were at their friends. Their daughter arrived back at 11p.m shortly before her parents. Police believe that the burglars gained access to the Jones' house through the study window situated on the ground floor at the back of the house. The window had been left unlocked. No one saw the burglars break in, although neighbours told the police that they had seen a white van parked across the street from the Jones' house before they had gone out to the pub at 9:30p.m. Police believe the burglars moved the picnic table in the back garden to underneath the study window in order to gain access to the house. Footprints in the mud suggest that there were three individuals present. Attached is a list of items that were stolen (they are underlined).

The binoculars had been in the conservatory, at the back of the house. They were used for spotting wildlife in the garden and were next to several nature and wildlife books.

The wristwatch had been upstairs in the master bedroom. It had been lying on the bedside table. The burglars had broken a lamp that was next to it.

The Game Boy had been in the children's room lying on the bed. The burglars never found the games for it, which were on the shelf.

The sunglasses had been in the kitchen next to the kettle and some holiday brochures.

They were an expensive designer pair bought last summer.

The television had been in the sitting room, which is situated at the front of the house.

It was sitting in the corner of the room. The remote control for it hadn't been taken.

The painting had been in the dining room, near a table with art books sitting on it. It had a silver engraved frame. An empty wallet was found near the table.

The printer had been in the study, which is at the back of the house. It was on a desk and the burglars had knocked the ream of paper that was next to it all over the floor.

The mobile phone had been in the hallway on the table charging its battery. An address book was beside it and the burglars had left the hall light switched on.

The coffee maker had been in the kitchen next to the tea, sugar jars and cappuccino mugs.

The china plate had been in the display case in the living room. It was the last remaining piece from a set that had been in the family for years.

Smith's House

The Smith's house had been burgled at Christmas. Mr. and Mrs. Smith and their daughter were out visiting relatives, while their son was at a friend's house playing computer games. The Smith's son arrived back home first to discover that they had been broken into. The rest of the family arrived back only a few minutes later at 10p.m. The police believe that the burglars broke in through the window in the master bedroom. The police suspect that the burglars used the ladders that were in the back garden in order to reach the window. No one saw the burglars break in although neighbours said that they had seen two individuals in a black van parked in front of the Smith's house at around 8p.m. They had noticed it when they were going to the

park to walk their dog although it had gone by the time they had returned. Attached is a list of items that were stolen (underlined).

The computer had been in the study, which is situated at the back of the house. It was on a desk but the burglars left the keyboard behind.

The video recorder had been on the floor in the sitting room. Movie magazines had been thrown about the room and one of the burglars had dropped a pack of Wrigley's gum.

The telescope had been temporarily set up in the conservatory next to several astronomy books and maps. It was in there while the attic was being renovated.

The rollerblades had been in the son's room. They were lying on the floor with the knee and elbow pads.

The necklace had been in the kitchen. It had been left by the sink in its presentation box. The burglars had smashed several plates on the floor.

The Discman had been on the dresser in the master bedroom. The burglars had knocked the headphones for it on to the floor.

The camcorder had been in the dining room and was lying on the table with the film of a friend's wedding.

The leather coat had been in the hallway. It was with the rest of the jackets on the coat rack by the front door. It belonged to a friend.

The crystal vase had been on the Welsh dresser in the sitting room. The flowers that had been in it had been thrown over the floor.

The microwave was in the kitchen. It had been set up on top of the fridge freezer.

Appendix A2

Retrieval Practice Questions

Jones' House

Set 1

1. This item is a type of hand held game.
2. Shades the eyes from the sunlight.
3. A portable communications device.
4. These pictures can be done in watercolour, oils or acrylics.
5. A small instrument that can be used to look at wildlife from a distance.
6. A box for watching programs and films on.
7. Makes hardcopies of documents.
8. This machine makes hot beverages.
9. This item from a dinner set is made from a fragile material.
10. A portable timepiece.

Set 2

1. A device using an electronic control to move points of light or the graphical symbols of a game on the screen of a visual display unit.
2. An output device that produces hardcopy results.
3. Electrical signals, converted from optical images and transmitted by UHF or VHF radio waves and reconverted into optical images by means of a "tube".
4. A pot in which water is infused with roasted or ground beans.
5. A ceramic ware of a type originally from the East.
6. This item has mechanical or electrically driven pointers that move constantly over a dial showing 12 numbers.

7. This wire frame contains darkened or polarised lenses that reduce the amount of light hitting the pupil.
8. An electronic device operated by cellular radio for transmitting speech, consisting of a microphone and receiver.
9. A canvas surface covered in a mixture consisting of pigments suspended in a liquid that dries on application.
10. An optical instrument for use with both eyes.

Set 3

1. The games were left behind for this device. What was it?
2. This set of visual protection was near some holiday brochures. What were they?
3. This personal communications system was beside an address book. What was it?
4. This artistic composition was framed in silver. What was it?
5. These "field glasses" were next to some wildlife books. What were they?
6. This fragile ceramic table item was in the display case. What was it?
7. This beverage-making machine was next to the tea and sugar jars. What was it?
8. The handset wasn't taken for this visual system. What was it?
9. The paper for this hardcopy machine was knocked onto the floor. What was it?
10. This "dial" was on the bedside table next to a lamp. What was it?

Smith's House

Set 1

1. They can be used for word processing, the Internet and games.
2. They are used to record programs and films.
3. This is an instrument used in astronomy.

4. This type of jewellery is worn around the neck.
5. This musical system plays compact disks.
6. This form of clothing is made from animal skins.
7. This item can be used to put flowers in.
8. This item is used to re-heat food.
9. This item captures events, such as weddings and birthdays, on tape as they happen.
10. This footwear is a style of inline skate.

Set 2

1. This device processes data according to a set of instructions, as well as storing data and performing arithmetical and logical operations at very high speeds.
2. Records on magnetic tape transmitted vision and sound signals.
3. An optical instrument for studying extra-terrestrial bodies that uses a combination of lenses and curved mirrors
4. A chain, band, or cord, often bearing beads or stones, worn as an ornament on the body.
5. A machine with optical laser beams for playing small digital audio discs on which sound is recorded as a series of metallic pits enclosed in PVC.
6. An outdoor garment made from a material made smooth by tanning.
7. An ornamental vessel made from a highly transparent and brilliant type of cut glass.
8. This hand held equipment captures live events by converting the optical image of a scene into the corresponding electrical signals and storing them on magnetic tape.

9. Cooks using electromagnetic radiation in the wavelength range of 0.3 to 0.001 metres.
10. A device that has clamps and straps for fastening to a boot or shoe and small wheels that enable the wearer to glide over the floor.

Set 3

1. The keyboard was left behind for this data storage system. What was it?
2. This play-back device was next to a set of movie magazines. What was it?
3. This "far seeing" instrument was next to some star maps. What was it?
4. The presentation box was left behind for this item, which is usually made of silver or gold. What was it?
5. This garment belonged to a friend. What was it?
6. The flowers from this cut glass container were thrown on the floor. What was it?
7. This device for recording live action shots was lying next to the film of a friend's wedding. What was it?
8. This oven, which cooks from the inside out, was on top of fridge freezer. What was it?
9. The headphones for this digital audio system were left behind. What was it?
10. The knee and elbow pads were left behind for this item with wheels. What was it?

Appendix A3

Experiment 1a: Independent t-tests to determine question set difficulty

	Mean Difference	t	df	p
Set 1 v Set 2	.238	4.302	6	.005
Set 1 v Set 3	.545	24.074	6	.001
Set 2 v Set 3	.308	5.664	6	.001

Appendix A4

Full List of Non-relevant Retrieval Practice Questions

The capital of Australia is Ca_____

The capital of Greece is At_____

The capital of Iraq is Ba_____

The capital of Canada is Ot_____

The capital of France is Pa_____

The capital of Eire is Du_____

The capital of Italy is Ro_____

The capital of Portugal is Li_____

The capital of Vietnam is Ho_____

The capital of Turkey is Is_____

The capital of Bulgaria is So_____

The capital of Chile is Sa_____

The capital of Argentina is Bu_____

The capital of Cuba is Ha_____

The capital of Albania is Al_____

The capital of Tunisia is Tu_____

The capital of Tasmania is Ho_____

The capital of Burma is Ra_____

The capital of Bangladesh is Da_____

The capital of Cambodia is Ph_____

The capital of Nigeria is La_____

The capital of Bolivia is La_____

The capital of Peru is Li_____

The capital of Philippines is Ma_____

Appendix A5

Free Recall

Please write down the names of the items that were stolen from both of the houses

Appendix A6

Additional Questioning Phase

Non-critical Questions

Jones' House

1. How did the burglars gain access to the Jones' house?
2. What time of year was it when the Jones' were broken into?
3. How many children do the Jones' have?
4. At what time did the Jones' neighbours see the van?

5. Where were the Jones' neighbours going to when they saw the van?
6. What object did the burglars use to climb up to reach the window of the Jones' house
7. Who were the Jones' children visiting?
8. What time did the Jones' get back at?
9. How many burglars broke into the Jones' house?
10. Where was the van parked that the Jones' neighbours saw?
11. What colour was the van that the Jones' neighbours saw?

Smith's House

1. How many burglars broke into the Smith's house?
2. Who were the Smith's children visiting?
3. What time of year was it when the Smiths were broken into?
4. Where was the van parked that the Smith's neighbours saw?
5. How many children do the Smiths have?
6. What colour was the van that the Smith's neighbours saw?
7. At what time did the Smith's neighbours see the van?
8. How did the burglars gain access to the Smith's house?
9. What object did the burglars use to climb up to reach the Smith's window?
10. What time did the Smiths get back at?
11. Where were the Smith's neighbours going to when they saw the van?

Critical Questions containing Misinformation

Jones' House

1. The burglars gained access to the Jones' house through the study window knocking the paper over for the scanner, which was on the desk. Where were Mr. and Mrs. Jones?
2. When the burglars stole the Jones' briefcase from their hallway, they also left the hallway light switched on. Who was the first home to find out that they had been burgled?
3. When the burglars stole the Jones' sculpture from their dining room they also stole the contents of a wallet. Where did they leave the empty wallet?
4. When the burglars stole the alarm clock that was on the bedside table in the Jones' master bedroom, they broke an item. What was broken?

Smith's House

1. The burglars gained access to the Smith's house through the master bedroom window, knocking the headphones for the Walkman of the dresser. Where were the Smiths?
2. When the burglars stole the earrings that were next to the sink in the kitchen, they knocked some items onto the floor breaking them. What did they break?
3. When the burglars stole the skateboard from the children's bedroom they knocked some safety equipment off the shelf. What were they?

4. When the burglars stole the DVD player from the living room they threw movie magazines over the room. They also dropped a pack of chewing gum. What was the brand?

Appendix A7

Forced-choice Recognition Test

Which of these items were stolen from the Jones' house:

- | | | |
|-------------------|-------------|------------|
| 1. printer | laptop | scanner |
| 2. mobile phone | filofax | briefcase |
| 3. carriage clock | alarm clock | wristwatch |
| 4. sculpture | figurine | painting |

Which of these items were stolen from the Smith's house:

- | | | |
|-----------------|------------|----------------|
| 1. Walkman | Discman | Mini Disc |
| 2. rollerblades | snow board | skateboard |
| 3. bracelet | earrings | necklace |
| 4. DVD player | monitor | video recorder |

Distracter Tasks

Appendix A8

Distracter Tasks from Retrieval Practice Schedule

Set 1

<u>2389</u>	<u>45910</u>	<u>891</u>	<u>785394</u>	<u>458</u>	<u>486</u>	<u>6458</u>	<u>1746</u>	<u>1674</u>
<u>+456</u>	<u>+1576</u>	<u>-47</u>	<u>+7891</u>	<u>x 8</u>	<u>+89</u>	<u>-487</u>	<u>x 10</u>	<u>-890</u>
<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>

<u>2)876106</u>	<u>1671</u> <u>x 4</u> <hr/>	<u>1671187</u> <u>+ 56901</u> <hr/>	<u>4)13968</u>
-----------------	------------------------------------	---	----------------

<u>10)45460</u>	<u>458</u> <u>-59</u> <hr/>	<u>3)8916</u>
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<u>4589</u>	<u>3895478</u>	<u>458</u>	<u>754692</u>	<u>7845</u>	<u>6720801</u>
<u>x 1</u>	<u>+ 99012</u>	<u>-78</u>	<u>+ 560</u>	<u>-846</u>	<u>+780210</u>
<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>

Set 2

<u>1958</u>	<u>89520</u>	<u>75136</u>	<u>7859123</u>	<u>78459621</u>
<u>+458</u>	<u>+4851</u>	<u>-4859</u>	<u>- 45892</u>	<u>- 1011</u>

<u>5)45682</u>	<u>45626</u> <u>+4578</u>	<u>4588956</u> <u>-458910</u>	<u>456</u> <u>x10</u>	<u>562378</u> <u>x 2</u>
----------------	------------------------------	----------------------------------	--------------------------	-----------------------------

<u>8)456</u>	<u>48546</u> <u>x 12</u> <hr/>	<u>9856</u> <u>-859</u> <hr/>	<u>99</u> <u>x9</u> <hr/>	<u>10023</u> <u>+8912</u> <hr/>
--------------	--------------------------------------	-------------------------------------	---------------------------------	---------------------------------------

<u>9)2727</u>	<u>78959</u> <u>-2023</u> <hr/>	<u>56891202</u> <u>+8925610</u> <hr/>	<u>7859</u> <u>x 11</u> <hr/>	<u>1631891</u> <u>x 3</u> <hr/>
---------------	---------------------------------------	---	-------------------------------------	---------------------------------------

458941285	1200325	156	895662	789613002
<u>+15615792</u>	<u>x</u> 6	<u>- 8</u>	<u>- 456</u>	<u>+45896137</u>

Set 3

Name Generation Task

A	e.g. alligator
B	
C	
D	
E	
F	
G	
H	
I	
J	
K	
L	
M	
N	
O	
P	
Q	
R	
S	
T	
U	
V	
W	
X	
Y	
Z	

Appendix A9

Distracter Following Free Recall: Word Generation

Black

A	
B	
C	
D	
E	
F	
G	
H	
I	
J	
K	
L	
M	
N	
O	
P	
Q	
R	
S	
T	
U	
V	
W	
X	
Y	
Z	

Wood

A	
B	
C	
D	
E	
F	
G	
H	
I	
J	
K	
L	
M	
N	
O	
P	
Q	
R	
S	
T	
U	
V	
W	
X	
Y	
Z	

Blue

A	
B	
C	
D	
E	
F	
G	
H	
I	
J	
K	
L	
M	
N	
O	
P	
Q	
R	
S	
T	
U	
V	
W	
X	
Y	
Z	

Round

A	
B	
C	
D	
E	
F	
G	
H	
I	
J	
K	
L	
M	
N	
O	
P	
Q	
R	
S	
T	
U	
V	
W	
X	
Y	
Z	

Green

A	
B	
C	
D	
E	
F	
G	
H	
I	
J	
K	
L	
M	
N	
O	
P	
Q	
R	
S	
T	
U	
V	
W	
X	
Y	
Z	

Appendix A10

Distracter Following Misinformation and Additional Questioning Phase

Name Generation Task

A	e.g. Australia
B	
C	
D	
E	
F	
G	
H	
I	
J	
K	
L	
M	
N	
O	
P	
Q	
R	
S	
T	
U	
V	
W	
X	
Y	
Z	

APPENDIX B

Statistical Tables for Experiment 1

Experiment 1a

MisRP+ Condition

Appendix B1

Experiment 1a: Single factor within subjects ANOVA for MisRP+ condition

Source	SS	df	MS	F	Sig	Eta Sq
Items	4.885	2	2.443	79.132	.001	.767
Error	1.482	48	.039			

Experiment 1a: Paired samples t-test for MisRP+ condition

	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
RP+ v NRP	.452	.271	.054	.340	.564	8.340	24	.001
RP- v NRP	-.148	.274	.055	-.261	-.035	-2.700	24	.012

MisRP- Condition

Appendix B2

Experiment 1a: Single factor within subjects ANOVA for MisRP- condition

Source	SS	df	MS	F	Sig	Eta Sq
Items	4.001	2	2.002	85.014	.001	.780
Error	1.130	48	.024			

Experiment 1a: Paired samples t-test for MisRP- condition

	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
RP+ v NRP	.384	.251	.050	.280	.488	7.877	24	.001
RP- v NRP	-.168	.184	.037	-.244	-.092	-4.560	24	.001

MisNRP Condition

Appendix B3

Experiment 1a: Single factor within subjects ANOVA for MisNRP condition

Source	SS	df	MS	F	Sig	Eta Sq
Items	4.174	2	2.087	67.104	.001	.737
Error	1.493	48	.031			

Experiment 1a: Paired samples t-test for MisNRP condition

	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
RP+ v NRP	.376	.291	.058	.256	.496	6.471	24	.001
RP- v NRP	-.192	.238	.048	-.290	-.094	-4.035	24	.001

Between Subject Comparisons

Appendix B4

Experiment 1a: Single factor between subjects ANOVA

Source	SS	df	MS	F	Sig	Eta Sq
Items	.382	3	.127	4.012	.010	.111
Error	3.044	96	.032			

Experiment 1a: Summary of independent t-tests comparing control condition to NRP items in each condition

	Mean	df	t	Sig
MisRP+	-.168	48	-3.251	.002
MisRP-	-.124	48	-2.854	.006
MisNRP	-.108	48	-2.680	.010

Appendix B5

Experiment 1a: Omnibus chi square

	Value	df	Sig
Pearson Chi Sq	14.667	3	.002
N	100		
Phi	.383		.002

0 cells have expected count less than 5. The minimum expected count is 7.50

Appendix B6

Experiment 1a: Chi square analysis and Phi value for MisRP+ condition versus control condition

	Value	df	Sig
Pearson Chi Sq	.500	1	.480
N	50		
Phi	.100		.480

0 cells have expected count less than 5. The minimum expected count is 5

Experiment 1a: Chi square analysis and Phi value for MisRP- condition versus control condition

	Value	df	Sig
Pearson Chi Sq	6.650	1	.010
N	50		
Phi	-.365		.010

0 cells have expected count less than 5. The minimum expected count is 10.50

Experiment 1a: Chi square analysis and Phi value for MisNRP condition versus control condition

	Value	df	Sig
Pearson Chi Sq	.117	1	.733
N	50		
Phi	.048		.733

0 cells have expected count less than 5. The minimum expected count is 5.50

Appendix B7

Experiment 1a: Chi square analysis and Phi value for MisRP- versus MisRP+ condition

	Value	df	Sig
Pearson Chi Sq	10.272	1	.001
N	50		
Phi	-.453		.001

0 cells have expected count less than 5. The minimum expected count is 9.50

Experiment 1a: Chi square analysis and Phi value for MisRP- versus MisNRP
condition

	Value	df	Sig
Pearson Chi Sq	8.333	1	.004
N	50		
Phi	-.408		.004

0 cells have expected count less than 5. The minimum expected count is 10.0

Additional Analysis

Appendix B8

Experiment 1a: Group statistics of output interference analysis

Condition	Output Order	N	Mean	Std. Dev	Std. Error Mean
MisRP+	Early RP+	12	-.133	.314	.091
	Early RP-	13	-.126	.254	.070
MisRP-	Early RP+	12	-.150	.207	.060
	Early RP-	13	-.185	.168	.047
MisNRP	Early RP+	12	-.142	.281	.081
	Early RP-	13	-.239	.190	.053

Experiment 1a: Paired samples t-test analysing output interference

Condition	t	df	Sig
MisRP+	.113	23	.911
MisRP-	.462	23	.649
MisNRP	1.017	23	.320

Appendix B9

Binoculars – Telescope
Wristwatsch – Necklace
Printer – Computer
Coffee Maker – Microwave
Painting – Vase
Mobile Phone – Discman
Sunglasses – Leather jacket
Television – Video recorder
Game Boy - Rollerblades

Appendix B10

Experiment 1a: Paired samples t-test of cross-category (NRP-Similarity based on RP+ items) analysis

Condition	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
MisRP+	-.022	.345	.069	-.164	.121	-.313	24	.757
MisRP-	.083	.378	.076	-.073	.239	1.102	24	.282
MisNRP	.077	.403	.081	-.090	.243	.952	24	.351

Appendix B11

Experiment 1a: Paired samples t-test of cross-category (NRP-Similarity based on RP-items) analysis

Condition	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
MisRP+	.093	.228	.046	-.012	.187	2.037	24	.053
MisRP-	-.020	.313	.063	-.131	.127	-.032	24	.975
MisNRP	.200	.673	.1347	-.078	.478	1.488	24	.150

Appendix B12

Experiment 1a: Paired samples t-test analysis of category dropout

Condition	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
MisRP+	-.048	.38	.068	-.188	.092	-.710	24	.485
MisRP-	-.012	.283	.057	-.130	.105	-.212	24	.834
MisNRP	-.052	.353	.071	-.198	.094	-.738	24	.468

APPENDIX C

Stimuli used in Experiment 1b

Recognition Task

Jones' House

Nintendo	vs.	GameBoy
painting	vs.	photo frame
wristwatch	vs.	calculator
videotapes	vs.	television
china plate	vs.	candleholder
wallet	vs.	sunglasses
mobile phone	vs.	answer-phone
coffee maker	vs.	wine glass
fax machine	vs.	printer
spectacles	vs.	binoculars

Smith's House

trainers	vs.	rollerblades
toaster	vs.	microwave
paperweight	vs.	crystal vase
necklace	vs.	bracelet
Discman	vs.	portable radio
DVD player	vs.	video recorder
computer	vs.	laptop
camcorder	vs.	modem
handbag	vs.	leather coat
magnifying glass	vs.	telescope

APPENDIX D

Statistical Table for Experiment 2

Appendix D1

Experiment 2a

Immediate Test Condition

Experiment 2a: Single factor within subjects ANOVA for Immediate Test condition

Source	SS	df	MS	F	Sig	Eta Sq
Items	9.778	2	4.889	57.033	.001	.663
Error	4.972	58	.086			

Experiment 2a: Paired samples t-test for Immediate Test condition

	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
RP+ v NRP	.614	.492	.090	.430	.798	6.839	29	.001
RP- v NRP	-.147	.392	.071	-.293	-.094	-2.058	29	.049

Appendix D2

Delayed Test Condition

Experiment 2a: Single factor within subjects ANOVA for Delayed Test condition

Source	SS	df	MS	F	Sig	Eta Sq
Items	.005	2	.025	.926	.402	.031
Error	4.553	58	.027			

Appendix D3

Experiment 2a: Group statistics of output interference analysis for Immediate Test condition

Condition	Output Order	N	Mean	Std. Dev	Std. Error Mean
Immediate Test	Early RP+	14	-.071	.385	.103
	Early RP-	16	-.26	.228	.006

Experiment 2a: Paired samples t-test analysing output interference

Condition	t	df	Sig
Immediate Test	2.370	28	.025

Appendix D4

Experiment 2a: Paired samples t-test of cross-category (NRP-Similarity based on RP+ items) analysis

Condition	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2-tailed)
				Lower	Upper			
Immediate Test	-.048	.347	.063	-.173	.082	-.752	29	.458

Appendix D5

Experiment 2a: Paired samples t-test of cross-category (NRP-Similarity based on RP-items) analysis

Condition	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
Immediate Test	.037	.290	.053	-.072	.145	.693	29	.494

Appendix D6

Experiment 2a: Paired samples t-test analysis of category dropout

Condition	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
Immediate Test	-.047	.351	.064	-.178	.084	-.728	29	.472
Delayed Test	-.033	.235	.043	-.124	.055	-.776	29	.444

Appendix D7

Experiment 2b

No Delay Condition

Experiment 2b: Single factor within subjects ANOVA for No Delay condition

Source	SS	df	MS	F	Sig	Eta Sq
Items	3.698	2	1.849	50.858	.001	.637
Error	2.109	58	.036			

Experiment 2b: Paired samples t-test for No Delay condition

	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
RP+ v NRP	.350	.242	.044	.260	.440	7.929	29	.001
RP- v NRP	-.130	.279	.051	-.234	-.257	-2.549	29	.016

Appendix D8

Delayed Practice Condition

Experiment 2b: Single factor within subjects ANOVA for Delayed Practice condition

Source	SS	df	MS	F	Sig	Eta Sq
Items	2.915	2	1.457	30.419	.001	.512
Error	2.779	58	.048			

Experiment 2b: Paired samples t-test for Delayed Practice condition

	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
RP+ v NRP	.287	.268	.049	.187	.387	5.870	29	.001
RP- v NRP	-.147	.337	.062	-.273	-.021	-2.383	29	.024

Appendix D9

Delayed Test Condition

Experiment 2b: Single factor within subjects ANOVA for Delayed Test condition

Source	SS	df	MS	F	Sig	Eta Sq
Items	.053	2	.026	.499	.610	.017
Error	3.079	58	.053			

Appendix D10

Experiment 2b: Chi square analysis and Phi value for No Delay condition

	Value	df	Sig
Pearson Chi Sq	5.934	1	.015
N	60		
Phi	-.314		.015

0 cells have expected count less than 5. The minimum expected count is 10.50

Experiment 2b: Chi square analysis and Phi value for Delayed Practice condition

	Value	df	Sig
Pearson Chi Sq	8.531	1	.003
N	60		
Phi	-.377		.003

0 cells have expected count less than 5. The minimum expected count is 11.50

Appendix D11

Additional Analysis

Experiment 2b: Group statistics of output interference analysis

Condition	Output Order	N	Mean	Std. Dev	Std. Error Mean
No Delay	Early RP+	15	-.127	.279	.067
	Early RP-	15	-.133	.290	.079
Delayed Practice	Early RP+	14	-.179	.197	.050
	Early RP-	16	-.131	.432	.108

Experiment 2b: Paired samples t-test analysing output interference

Condition	t	df	Sig
No Delay	.064	28	.949
Delayed Practice	.377	28	.709

Appendix D12

Experiment 2b: Paired samples t-test of cross-category (NRP-Similarity based on RP+ items) analysis

Condition	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
No Delay	.117	.372	.064	-.014	.248	1.826	29	.078
Delayed Practice	-.010	.340	.066	-.144	.125	-.147	29	.884

Appendix D13

Experiment 2b: Paired samples t-test of cross-category (NRP-Similarity based on RP- items) analysis

Condition	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
No Delay	-.050	.337	.062	-.176	.076	-.807	29	.426
Delayed Practice	.110	.305	.056	-.003	.224	1.983	29	.057

Appendix D14

Experiment 2b: Paired samples t-test analysis of category dropout

Condition	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
No Delay	-.033	.407	.074	-.185	.119	-.448	29	.657
Delayed Practice	.040	.285	.052	-.066	.146	.769	29	.448
Delayed Test	-.013	.315	.057	-.131	.104	-.232	29	.818

APPENDIX E

Stimuli used in Experiment 3

Appendix E1

Pilot study to determine similarity between items:

Can you please group these items by similarity and write down why you think that they are similar. For example, if apple, banana, and orange were present on the list they could be classed as "fruits", while orange, football and wheel are all items that are "round". Each item can belong to as many groups as you want (e.g., orange belonged to the groups "fruit" and "round").

Binoculars
Sunglasses
Coffee maker
Filofax
Tennis racket
Wallet
Fax machine
Desk
Chisel
Nintendo
Bicycle
Sculpture
Television
Rocking chair
Shoulder bag
Skate board
Earrings
MP3 Player
Waterproof jacket
Armchair
Hairdryer
Pearls
Figurine
Mirror
Wristwatch
Guitar
Lamp
Trainers
Perfume

Game Boy
Drawers
China plate
Jeans
Laptop computer
Bracelet
Snow board
Walkman
Letter opener
Kettle
Wedding ring
Mini Disc
Denim jacket
Golf clubs
DVD player
Briefcase
Microwave
Screwdriver
Paperweight
Signet ring
Hockey stick
Violin
Toaster
Skirt
Sofa
Filing cabinet
Necklace
Vase
Sweater

Table
Rucksack
Mobile phone
Painting
Leather jacket
Clock
Printer
Stereo
Camera
Video recorder
Shirt
Discman
Engagement ring

PlayStation
Hammer
Fountain pen
Telescope
Bookcase
Keyboard
Calculator
Cuff links
Desktop Computer
Rollerblades
Locket
Camcorder

Significant groupings of items (where at least 50% of participants identified groupings or dominant features

Items	Dominant features identified
Leather jacket ^a , denim jacket ^a , waterproof jacket ^a , trainers ^a , Shirt ^b , sweater ^b , jeans ^b , skirt ^b	Clothing ^a Outdoor clothing ^b Indoor clothing
Television ^a , DVD player ^a , video recorder ^a , Nintendo ^b , GameBoy ^b , PlayStation ^b	Entertainment ^a Related to TV ^b Playing games on
Rocking chair ^a , armchair ^a , sofa ^a , drawers ^b , table, bookcase ^b , desk ^b	Furniture ^a Chairs, things to sit on ^b Storage, put things in
Tennis racket, bicycle, skateboard, snowboard, golf clubs, hockey stick, rollerblades	Sports items/items associated with exercise
Filofax, fax machine, printer, laptop computer, letter opener, briefcase, paperweight, fountain pen, calculator, desktop computer, bookcase ^a , filing cabinet ^a , desk ^a	Office equipment ^a Office furniture
Tennis racket, golf clubs, bicycle, shoulder bag, rucksack, briefcase	Has handles
Wallet, shoulder bag, rucksack, briefcase	Luggage, used to carry other items
Chisel, screwdriver, hammer	tools
Guitar, violin, keyboard	Musical instruments
Hairdryer, mirror, perfume, wedding ring, necklace, earrings	Things found in a bathroom
Locket ^a , necklace ^a , pearls ^a , signet ring ^b , wedding ring ^b , engagement ring ^b , bracelet, earrings, cufflinks, wristwatch	Jewellery ^a Worn round the neck ^b Worn on the finger
Coffee maker, toaster, kettle, microwave	Items found in a kitchen
Hairdryer, lamp, perfume, clock, drawers	Items typically found in a bedroom

Sculpture ^a , painting ^a , figurine ^a , Vase, paperweight, china plate	Decorative ^a Items of fine art
Discman, stereo, MiniDisc, Walkman, MP3 player	Stereo/audio equipment

Appendix E2

Study Materials: Narratives

Thompson's House

Mr. and Mrs. Thompson and their twelve year old daughter Elizabeth live in the country. During the school holidays the Thompson's spent a week in Italy. On arriving back from their vacation, they discovered that their house had been broken into during their absence. Once the police arrived, the family was asked to take an inventory of all the missing items. Due to the dry weather that week tyre tracks were found in the dirt of the drive and the police believed that this indicated that the burglar or burglars had been driving a van. The police also believe that the burglar or burglars broke into the house through the patio doors.

Attached is a list of items that where stolen (the items are underlined).

The hockey stick had been stored in the cupboard in the hallway. It had belonged to the daughter who had been part of the school's team.

The mobile phone had been in the hallway. It had belonged to Mr. Thompson who needed it for his job as a doctor.

The Playstation had been in the sitting room. It had been lying on the floor.

The armchair had been in the sitting room. It had been next to the patio doors.

The guitar had been in the daughter's room. She had been learning to play.

The painting had been in the dining room. It had been framed in the middle of the wall.

The microwave had been in the kitchen. It had been by the window.

The lamp had been in the kitchen. It had been in the corner of the room.

The necklace had been in the master bedroom. It had been in a red presentation box.

The vase had been in the sitting room. It had been on the window ledge.

Williams' House

Mr. and Mrs. Williams and their sixteen year old son, Jack, live in the suburbs of a city. On New Year's Day, Mr. and Mrs. Williams dropped their son off at a friend's house for the evening and then went to relatives. On arriving back at 10pm the Williams discovered that they had been burgled. Once the police arrived, the family where asked to take an inventory of all the missing items. After the police had examined the area, they believed that the burglars had gained access to the house by breaking the study window. Footprints in the snow also suggested that there were two burglars.

Attached is a list of items that where stolen (the items are underlined).

The perfume had been in the bathroom. It had belonged to Mrs. Williams and had been a Christmas gift.

The rucksack had been in the son's bedroom. It had been in his school bag but the police believe that the burglars had used it for carrying small items.

The hammer had been in the workshop. It had been lying on the floor.

The fountain pen had been in the study. Mrs. Williams is a teacher and used it to mark schoolwork.

The telescope had been in the conservatory. It had been set up so that it was pointing at the sky.

The leather jacket had been in the son's bedroom. It had been hanging from a clothes hook on the wall.

The clock had been in the bathroom. It had been hanging on the wall.

The printer had been in the study. It had been a Christmas present for the Williams' son.

The calculator had been in the study. The Williams use it for their accounts.

The stereo had been in the son's bedroom. It had been on a shelf.

Appendix E3

Retrieval Practice

Thompson's House

Set 1

1. This item was in the Thompson's House, and has 6 strings, a fretted fingerboard and a flat sounding board with a circular hole in the centre.
2. This item was in the Thompson's House, and is a long stick with a curved end that is used to hit a ball.
3. This item was in the Thompson's House, and is a device for giving light via an electric bulb.
4. This item was in the Thompson's House, and is a container for holding flowers.
5. This item was in the Thompson's House, and individuals sit on this item.
6. This item was in the Thompson's House, and is a portable communications device.
7. This item was in the Thompson's House, and is an artistic composition.
8. This item was in the Thompson's House, and is used for playing games on. This special unit is plugged into a TV and has manual controls for one or two players.

9. This item was in the Thompson's House, and is usually made of an inert metal and/or semi-precious stones that loops around the neck.
10. This item was in the Thompson's House, and is used to cook, re-heat and defrost food.

Set 2

1. This item was in the Thompson's House, and produces notes when it's strings are plucked
2. This item was in the Thompson's House, and is used to play a field game where 2 opposing teams of 11 players each try to hit a ball into their opponent's goal.
3. This item was in the Thompson's House, and produces illumination.
4. This item was in the Thompson's House, and is a decorative container.
5. This item was in the Thompson's House, and has 2 arms and 4 legs.
6. This item was in the Thompson's House, and is an electronic device operated by cellular radio for transmitting speech
7. This item was in the Thompson's House, and is a canvas composed in watercolour, oils or acrylics.
8. This item was in the Thompson's House, and is a brand of game.
9. This item was in the Thompson's House, and is a chain, band, or cord, often bearing beads or stones, worn as an ornament around the neck area.
10. This item was in the Thompson's House, and is a machine that cooks food very quickly

Set 3

1. This item was in the Thompson's House, and was invented by Spanish musicians in the 17th century
2. This item was in the Thompson's House, and is a piece of sporting apparatus that was invented in the 19th century.
3. This item was in the Thompson's House, and can be found in electric, gas and oil types.
4. This item was in the Thompson's House, and is an ornamental vessel.
5. This item was in the Thompson's House, and is an upholstered item.
6. This item was in the Thompson's House, and consists of a microphone and receiver.
7. This item was in the Thompson's House, and is a surface covered in a mixture consisting of solid pigments suspended in a liquid that dries after application.
8. This item was in the Thompson's House, and is a device that uses electronic controls to move points of light or graphical symbols of a game about on a screen.
9. This item was in the Thompson's House, and is worn around the neck.
10. This item was in the Thompson's House, and is an appliance that produces electro-magnetic radiation in the wavelength range of 0.3 to 0.001 metres.

Williams' House

Set 1

1. This item was in the Williams' House, and is a fragrance.
2. This item was in the Williams' House, and is a timepiece for a wall or mantelpiece.

3. This item was in the Williams' House, and is an outdoor garment is made from animal skin.
4. This item was in the Williams' House, and is an instrument used in astronomy.
5. This item was in the Williams' House, and is a piece of audio equipment short for "stereophonic"
6. This item was in the Williams' House, and is a type of large bag.
7. This item was in the Williams' House, and is a long thin object that contains ink.
8. This item was in the Williams' House, and is a machine that uses ink to produce letters, numbers, words, or symbols on paper.
9. This item was in the Williams' House, and is used for driving nails into wood.
10. This item was in the Williams' House, and is an electronic mathematical device that can be held in the palm of the hand.

Set 2

1. This item was in the Williams' House, and is a liquid with a pleasant smell.
2. This item was in the Williams' House, and is a device for measuring and showing time.
3. This item was in the Williams' House, and is a garment made from a material made smooth by tanning.
4. This item was in the Williams' House, and is an optical instrument for studying extra-terrestrial bodies.
5. This item was in the Williams' House, and is a music system that usually comes with a cassette player, CD player and a set of speakers.
6. This item was in the Williams' House, and usually has 2 straps for carrying it on the back.

7. This item was in the Williams' House, and when pressure is placed on the nib, ink is produced on paper
8. This item was in the Williams' House, and is an output device that produces hardcopy results.
9. This item was in the Williams' House, and is an item used in carpentry.
10. This item was in the Williams' House, and is a device for performing mathematical calculations.

Set 3

1. This item was in the Williams' House, and is a mixture of alcohol and essential oils extracted from flowers, spices, etc, or made synthetically.
2. This item was in the Williams' House, and has mechanical or electrically driven pointers that move constantly over a dial showing 12 numbers.
3. This item was in the Williams' House, and is worn around the upper body and is usually either waist or hip length with an opening that runs from the neck to the hem.
4. This item was in the Williams' House, and is a cylindrical device that uses a combination of lenses and/or curved mirrors
5. This item was in the Williams' House, and is a piece of equipment for playing music on.
6. This item was in the Williams' House, and has a supporting frame so that it can be carried by campers and climbers.
7. This item was in the Williams' House, and the point of this item is supplied with a coloured liquid from the cartridge inside the barrel
8. This item was in the Williams' House, Produces hard copies of documents.

9. This item was in the Williams' House, and is a heavy steel head with a flattened end held transversely on the end of a wooden handle.
10. This item was in the Williams' House, and is a small device that is used for doing calculations.

Appendix E4

Experiment 3: Independent t-tests to determine question set difficulty

	Mean Difference	t	df	Sig
Set 1 v Set 2	.342	19.300	8	.001
Set 1 v Set 3	.632	10.978	8	.001
Set 2 v Set 3	.290	4.988	8	.001

Appendix E5

Pilot work examining the appropriateness of category labels (using same items in Appendix E1)

For this task we'd like you to match the items on the following page to the category labels in the tables. We believe that all of these items can fit under one of these 18 category labels, however, if you can think of a better label for an item then please write it down in one of the blank tables. Even if it is just one item that you don't think is suited to any of these category labels it is important that you write it down.

Also, could you indicate which item you think is the best example of the category and which item you think is the worst example of the category (this item would probably be an item you think is better described by another category label).

For example, if “apple” was on this list, you might think that the item fits best under the category label “FRUIT” but poorly under the category “ROUND”

Sports Equipment	Clothing	Jewellery
1.	1.	1.
2.	2.	2.
3.	3.	3.
4.	4.	4.
5.	5.	5.
6.	6.	6.

Furniture	Computer Equipment	Technology
1.	1.	1.
2.	2.	2.
3.	3.	3.
4.	4.	4.
5.	5.	5.
6.	6.	6.

Musical Instrument	Audio Equipment	Tool
1.	1.	1.
2.	2.	2.
3.	3.	3.
4.	4.	4.
5.	5.	5.
6.	6.	6.

Cookware	Kitchenware	Baggage
1.	1.	1.
2.	2.	2.
3.	3.	3.
4.	4.	4.
5.	5.	5.
6.	6.	6.

Office Equipment	Decorative	Art
1.	1.	1.
2.	2.	2.
3.	3.	3.
4.	4.	4.
5.	5.	5.
6.	6.	6.

Bathroom Equipment	Bedroom Items	Sitting Room
1.	1.	1.
2.	2.	2.
3.	3.	3.
4.	4.	4.
5.	5.	5.
6.	6.	6.

These would be better category names for these items....

1.	1.	1.
2.	2.	2.
3.	3.	3.
4.	4.	4.
5.	5.	5.
6.	6.	6.
7.	7.	7.
8.	8.	8.

Mean rankings assigned by participants for pilot items (1 indicating item is best example of category, and 6 and above indicating item is worst example of category)

Sports Equipment	Clothing	Jewellery
1. tennis racket	1. jeans	1. necklace
2. hockey stick	2. shirt	2. earrings
3. golf clubs	3. sweater	3. wedding ring
4. bicycle	4. denim jacket	4. bracelet
5. skateboard	5. trainer	5. engagement ring
6. snowboard	6. skirt = leather jacket	6. watch = cufflinks
7. rollerblades	8. waterproof jacket	8. pearls = locket
		10. signet ring

Furniture	Computer Equipment	Technology
1. armchair	1. desktop computer	1. desktop computer
2. sofa	2. printer	2. printer
3. table	3. laptop computer	3. laptop computer = DVD player
4. bookcase = desk	4. Nintendo	5. Nintendo
6. drawers	5. PlayStation = GameBoy	6. PlayStation
7. rocking chair	7. fax machine	7. GameBoy
8. filing cabinet		8. mobile phone

Musical Instrument	Audio Equipment	Tool
1. guitar 2. violin 3. keyboard 4. 5. 6.	1. stereo 2. Walkman = Discman 3. MP3 player 4. MiniDisc 5. keyboard 6.	1. hammer 2. screwdriver 3. chisel 4. letter opener 5. 6.

Cookware	Kitchenware	Baggage/Luggage
1. toaster 2. microwave 3.	1. kettle 2. toaster 3. microwave = coffee maker	1. rucksack 2. shoulder bag 3. briefcase 4. wallet

Office Equipment	Decorative	Art
1. desktop computer 2. desk 3. printer 4. briefcase = filing cabinet 6. fax machine = filofax 8. calculator = bookcase 11. fountain pen = paperweight 12. mobile phone	1. painting 2. vase 3. china plate 4. figurine = sculpture 6. paperweight 7. mirror	1. painting 2. sculpture 3. figurine 4. vase 5. china plate 6.

Bathroom Equipment	Bedroom Items	Sitting Room
1. mirror 2. hairdryer 3. perfume 4. 5. 6.	1. clock 2. drawers 3. mirror = lamp 5. hairdryer 6. television = perfume 8. jeans 9. sweater	1. sofa 2. television = armchair 4. DVD player 5. video recorder = stereo 7. lamp 8. painting = Nintendo 10. figurine

These would be better category names for these items....

Items used to contain things (in addition to luggage items)	Rectangular in shape	Games/gaming equipment
1. vase (keeps flowers) 2. kettle (keeps water) 3. coffee maker (keeps coffee) 4. filofax (keeps info) 5. locket (keeps photos) 6. 7. 8.	1. laptop 2. DVD player 3. video recorder 4. briefcase 5. filofax 6. calculator 7. television 8. microwave 9. toaster 10. filing cabinet	1. Nintendo 2. PlayStation = GameBoy 4. Desktop 5. 6. 7. 8.

Look through to make things bigger/magnifies	Ornaments	Performs calculations, mathematical device
1. binoculars 2. telescope 3. 4. 5.	1. vase 2. china plate 3. figurine 4. sculpture 5. paperweight	1. calculator 2. desktop computer (stats) 3. laptop computer 4. 5.

Used for communicating with others	Audio-visual	Photography Equipment
1. mobile phone 2. fax machine 3. fountain pen (writing letters) 4. desktop computer (e-mailing) 5.	1. stereo 2. DVD player 3. television 4. video recorder 5. Discman 6. walkman 7. MP3 player	1. camera 2. camcorder 3. 4. 5. 6. 7.

Measures time	Used to write	Illuminates, lights up the dark
1. Clock 2. Wristwatch	1. Fountain pen 2. Desktop computer 3. Laptop computer	1. Lamp

Fragrance
1. Perfume

Appendix E6

Independent Probe Cued-recall

MATHEMATICAL DEVICE-Ca_____

COMPUTER HARDWARE-Pr_____

COOKWARE-Mi_____

ART-Pa_____

BAGGAGE-Ru_____

TOOL-Ha_____

CLOTHING-Le_____

FRAGRANCE-Pe_____

CONTAINER-Va_____

TIME PIECE-Ci_____

GAME-Pi_____

COMMUNICATIONS DEVICE-Mo_____

MAGNIFICATION EQUIPMENT-Te_____

ILLUMINATION DEVICE-La_____

AUDIO EQUIPMENT-St_____

FURNITURE-Ar_____

WRITING IMPLIMENT-Fo_____

SPORTS EQUIPMENT-Ho_____

MUSICAL INSTRUMENT-Gu_____

JEWELLERY-Ne_____

Appendix E7

Distracter Tasks

Distracter Tasks from Retrieval Practice Schedule

Set 1: Fruit

AMONG.....	mango
BREW STARRY.....	strawberry
GO NEAR.....	orange
LAPEP.....	apple
HER CRY.....	cherry
ANNA BA.....	banana
ALERT WOMEN.....	watermelon
PERRY BARS.....	raspberry
PAGER.....	grape
LUMP.....	plum
CHEAP.....	peach
RIP COAT.....	apricot
DAMN RAIN.....	mandarin
A MOTTO.....	tomato
BLUNT CARRACK.....	blackcurrant
ROGER OBEYS.....	gooseberry
REAP.....	pear
PLANE PIPE.....	pineapple
PUN ER.....	prune
ELIM.....	lime
AT ED.....	date

GIF.....fig
 WIKI.....kiwi
 BAH BURR.....rhubarb
 TUN COCO.....coconut

Set 2: Vegetables

LET CUTE.....lettuce
 STUPORS.....sprouts
 LUCIFOR AWOL.....cauliflower
 PEP REP.....pepper
 CRUMB CUE.....cucumber
 CUTTER OGE.....courgette
 MOMS HOUR.....mushroom
 RUG BEANIE.....aubergine
 SNAP CHI.....spinach
 I NOON.....onion
 COOL CRIB.....broccoli
 CHUNKY EAR.....curly kane
 TETANUS WRETCH.....water chestnut
 BOOM BA.....bamboo
 PRECHILL PIPE.....chilli pepper
 OAT POT.....potato
 TREE BOOT.....beetroot
 CENSOR WET.....sweet corn
 PLAYERS.....parsley

SLEEK.....	leeks
CRY EEL.....	celery
SPINS RAP.....	parsnips
COAT HIKER.....	artichoke
SIR HAD.....	radish
ELMS ORGANS.....	lemongrass
MINK PUP.....	pumpkin
LASH LOTS.....	shallots

Set 3: Academic Subjects

MAYAN TO.....	anatomy
LOGY ZOO.....	zoology
SHY TRIO.....	history
BOGY OIL.....	biology
METRIC SHY.....	chemistry
ENGRAM.....	german
GNOMIC PUT.....	computing
NIDI TIVY.....	divinity
LEG SHIN.....	english
PAY HOGGER.....	geography
KEG ER.....	greek
CHOLERA YOGA.....	archaeology
MISMATCH TEA.....	mathematics
GLOOMY SOC.....	cosmology
CH FREN.....	french

LOGY EGO.....	geology
INSECURE CONE.....	neuroscience
HOLY HIPPOS.....	philosophy
A LINT.....	latin
ART PHONOLOGY.....	anthropology
PSYCH SI.....	physics
ARMY TOONS.....	astronomy
MICE DINE.....	medicine
GYPSY CHOLO.....	psychology
RAINS US.....	russian
ITS STATICS.....	statistics
COMIC NOSE.....	economics
MAGENTA MEN.....	management
SASH PIN.....	sash pin
ANOINTER REINSTALLATIO.....	international relations
SYMBIOTIC HER.....	biochemistry
DIRTY NEST.....	dentistry
TINA ALI.....	italian
ALLIED GUESTS.....	legal studies

APPENDIX F

Appendix F1

Experiment 3: Single factor within subjects ANOVA

Source	SS	df	MS	F	Sig	Eta Sq
Items	3.751	2	1.875	22.695	.001	.486
Error	3.967	48	.083			

Experiment 3: Paired samples t-test

	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
RP+ v NRP	.364	.417	.008	.192	.536	4.369	24	.001
RP- v NRP	-.172	.412	.008	-.343	-.002	-2.089	24	.048

Appendix F2

Experiment 3: Independent samples t-test

	t	df	Sig (2-tailed)	Mean Diff.	Std. Error Diff	95% Confidence Interval	
						Lower	Upper
NRP v Control	.273	48	.786	.016	.059	-.102	.134

APPENDIX G

Stimuli used in Experiment 4

Appendix G1

Study Materials: Narratives

Thompson's House

Mr. and Mrs. Thompson and their twelve-year old daughter Elizabeth live in the country. During the school holidays the Thompson's spent a week in Italy. On arriving back from their vacation, they discovered that their house had been broken into during their absence. Once the police arrived, the family were asked to take an inventory of all the missing items. Due to the dry weather that week the police found tyre track marks in the dirt of the drive and they believed that the burglar or burglars had been driving a van. The police also believe that the burglar or burglars broke into the house through the patio doors.

Below is a description of items that were stolen (the items are underlined)

The hockey stick had been in the cupboard in the hallway. It had belonged to the daughter who had been part of the school's team.

The mobile phone had been in the hallway. It had belonged to Mr. Thompson who needed it for his job as a doctor.

The Playstation had been in the sitting room. It had been lying on the floor.

The armchair had been in the sitting room. It had been next to the patio doors.

The guitar had been in the daughter's room. She had been learning to play.

The jeans had been in the daughter's room. They had been lying on the floor.

The painting had been in the dining room. It had been framed in the middle of the wall.

The table had been in the dining room. The Thompson family ate their breakfast at it every morning.

The microwave had been in the kitchen. It had been by the kitchen window.

The lamp had been in the kitchen. It had been in the corner of the room.

The sweater had been in the master bedroom. It had been hung on a clothes hook on the back of the door.

The necklace had been in the master bedroom. It had been in a red presentation box.

The earrings had been in the daughter's room. They had been in a small jewellery box.

The vase had been in the sitting room. It had been on the window ledge.

Williams' House

Mr. and Mrs. Williams and their sixteen-year old son, Jack, live in the suburbs of a city. On New Year's Day Mr. and Mrs. Williams dropped their son off at a friend's house for the evening and then went to relatives. On arriving back at 10pm, the Williams discovered that they had been burgled. Once the police arrived the family were asked to take an inventory of all the missing items. After the police had examined the area, they believed that the burglars had gained access to the house by breaking the study window. Footprints in the snow also suggested that there were two burglars.

Below is a description of items that were stolen (the items are underlined)

The cuff links had been in the master bedroom. Mr Williams wore them on formal occasions.

The perfume had been in the bathroom. It had belonged to Mrs. Williams and had been a Christmas gift.

The trainers had been in the workshop. Mr. Williams had just bought them in the sales.

The rucksack had been in the son's bedroom. It had been his school bag but the police believe that the burglars had used it to carry small items in.

The hammer had been in the workshop. It had been lying on the floor.

The fountain pen had been in the study. Mrs. Williams is a teacher and used it to mark schoolwork.

The camera had been in the conservatory. It had been set up on a tripod.

The telescope had been in the conservatory. It had been set up so that it was pointing at the sky.

The leather jacket had been in the son's bedroom. It had been hung on a clothes hook on wall.

The clock had been in the bathroom. It had been hung on the wall.

The wedding ring had been in the bathroom. Mrs. Williams has arthritis and had left it by the sink.

The desk had been in the study. Mrs. Williams is a teacher and prepares her lessons at it.

The bookcase had been in the master bedroom. It had been by the door.

The stereo had been in the son's bedroom. It had been on a shelf.

Appendix G2

Retrieval Practice Questions

Thompson's House

Set 1

1. This item was in the Thompson's House, and has 6 strings, a fretted fingerboard and a flat sounding board with a circular hole in the centre.
2. This item was in the Thompson's House, and is a long stick with a curved end that is used to hit a ball.
3. This item was in the Thompson's House, and is a device for giving light via an electric bulb.
4. This item was in the Thompson's House, and is a container for holding flowers.
5. This item was in the Thompson's House, and individuals sit on this item.
6. This item was in the Thompson's House, and has a horizontal surface for placing objects on.
7. This item was in the Thompson's House, and is an artistic composition.
8. This item was in the Thompson's House, and is used for playing games on. This special unit is plugged into a TV and has manual controls for one or two players.
9. This item was in the Thompson's House, and is used to cook, re-heat and defrost food.
10. This item was in the Thompson's House, and is a portable communications device.
11. This item was in the Thompson's House, and is usually made of an inert metal and/or semi-precious stones that loops around the neck.
12. This item was in the Thompson's House, and is worn on the fleshy lower part of the ear.

13. This item was in the Thompson's House, and is made from denim
14. This item was in the Thompson's House, and is a knitted item that is usually worn in the winter to keep warm.

Set 2

1. This item was in the Thompson's House, and produces notes when it's strings are plucked
2. This item was in the Thompson's House, and is used to play a field game where 2 opposing teams of 11 players each try to hit a ball into their opponent's goal.
3. This item was in the Thompson's House, and produces illumination.
4. This item was in the Thompson's House, and is a decorative container.
5. This item was in the Thompson's House, and has 2 arms and 4 legs.
6. This item was in the Thompson's House, and is a slab or board supported by 4 legs
7. This item was in the Thompson's House, and is a canvas composed in watercolour, oils or acrylics.
8. This item was in the Thompson's House, and is a brand of game.
9. This item was in the Thompson's House, and is a machine that cooks food very quickly.
10. This item was in the Thompson's House, and is an electronic device operated by cellular radio for transmitting speech.
11. This item was in the Thompson's House, and is a chain, band, or cord, often bearing beads or stones, worn as an ornament around the neck area.
12. This item was in the Thompson's House, and is an ornament for the ear.
13. This item was in the Thompson's House, and is a form of casual trousers.

14. This item was in the Thompson's House, and is worn indoors on the upper part of the body.

Set 3

1. This item was in the Thompson's House, and was invented by Spanish musicians in the 17th century
2. This item was in the Thompson's House, and is a piece of sporting apparatus that was invented in the 19th century.
3. This item was in the Thompson's House, and can be found in electric, gas and oil types.
4. This item was in the Thompson's House, and is an ornamental vessel.
5. This item was in the Thompson's House, and is an upholstered item.
6. This item was in the Thompson's House, and has a flat surface.
7. This item was in the Thompson's House, and is a surface covered in a mixture consisting of solid pigments suspended in a liquid that dries after application.
8. This item was in the Thompson's House, and is a device that uses electronic controls to move points of light or graphical symbols of a game about on a screen..
9. This item was in the Thompson's House, and is an appliance that produces electro-magnetic radiation in the wavelength range of 0.3 to 0.0001 metres.
10. This item was in the Thompson's House, and consists of a microphone and receiver.
11. This item was in the Thompson's House, and is worn around the neck.
12. This item was in the Thompson's House, and has a "stalk" and "butterfly".
13. This item was in the Thompson's House, and is a types of trousers made from hard-wearing twill-weave cotton fabric.

14. This item was in the Thompson's House, and is a woollen garment.

Williams' House

Set I

1. This item was in the Williams' House, and is a device for taking photographs.
2. This item was in the Williams' House, and is a fragrance.
3. This item was in the Williams' House, and is a timepiece for a wall or mantelpiece.
4. This item was in the Williams' House, and is an outdoor garment is made from animal skin.
5. This item was in the Williams' House, and forms a pair of linked buttons that are used to join the buttonholes of the cuffs of men's shirts.
6. This item was in the Williams' House, and is an instrument used in astronomy.
7. This item was in the Williams' House, and has a writing surface, as well as drawers and other compartments for storing paperwork.
8. This item was in the Williams' House, and contains shelves for storing books.
9. This item was in the Williams' House, and is usually worn on the finger and is made of a valuable yellow coloured metal.
10. This item was in the Williams' House, and is a piece of audio equipment short for "stereophonic"
11. This item was in the Williams' House, and is manufactured by the likes of Nike, Adidas, and Reebok.
12. This item was in the William's House, and is a type of large bag.
13. This item was in the Williams' House, and is used for driving nails into wood.
14. This item was in the Williams' House, and is a long thin object that contains ink.

Set 2

1. This item was in the Williams' House, and records pictures onto film.
2. This item was in the Williams' House, and is a liquid with a pleasant smell.
3. This item was in the Williams' House, and is a device for measuring and showing time.
4. This item was in the Williams' House, and is a garment made from a material made smooth by tanning.
5. This item was in the Williams' House, and is worn through the cuffs of a shirt.
6. This item was in the Williams' House, and is an optical instrument for studying extra-terrestrial bodies.
7. This item was in the Williams' House, and individuals can sit at this item to work or to use a computer.
8. This item was in the Williams' House, and is used to contain books that are organised into alphabetical order.
9. This item was in the Williams' House, and is a band of yellow metal often exchanged in wedding ceremonies.
10. This item was in the Williams' House, and is a music system that usually comes with a cassette player, CD player and a set of speakers.
11. This item was in the Williams' House, and is a type of shoe primarily used when performing sports or leisure activities.
12. This item was in the Williams' House, and usually has 2 straps for carrying it on the back.
13. This item was in the Williams' House, and is used in carpentry.
14. This item was in the Williams' House, and ink is produced on paper when pressure is placed on the nib.

Set 3

1. This item was in the Williams' House, and is an optical device consisting of a lens system and a highly sensitive film.
2. This item was in the Williams' House, and is a mixture of alcohol and essential oils extracted from flowers, spices, etc, or made synthetically.
3. This item was in the Williams' House, and has mechanical or electrically driven pointers that move constantly over a dial showing 12 numbers.
4. This item was in the Williams' House, and is worn around the upper body and is usually either waist or hip length with an opening that runs from the neck to the hem.
5. This item was in the Williams' House, and is worn by men primarily for formal events.
6. This item was in the Williams' House, and is a cylindrical device that uses a combination of lenses and/or curved mirrors
7. This item was in the Williams' House, and is an item that is highly associated with office work.
8. This item was in the Williams' House, and houses large numbers of items containing printed pages that are bound together.
9. This item was in the Williams' House, and is a circular band of inert metal.
10. This item was in the Williams' House, and is a piece of equipment for playing music on.
11. This item was in the Williams' House, and can be worn on the feet.
12. This item was in the Williams' House, and has a supporting frame so that it can be carried by campers and climbers.

13. This item was in the Williams' House, and its point is supplied with a coloured liquid from the cartridge inside the barrel.

14. This item was in the Williams' House, and has a heavy steel head with a flattened end held transversely on the end of a wooden handle.

Appendix G3

Independent Probe Cued-recall Test

CLOTHING-Je_____

FURNITURE-Bo_____

COOKWARE-Mi_____

PHOTOGRAPHY EQUIPMENT-Ca_____

ART-Pa_____

BAGGAGE-Ru_____

FURNITURE-Ta_____

CLOTHING-Le_____

FRAGRANCE-Pe_____

CONTAINER-Va_____

TIME PIECE-CI_____

GAME-Pl_____

CLOTHING-Sw_____

FURNITURE-De_____

COMMUNICATIONS DEVICE-Mo_____

MAGNIFICATION EQUIPMENT-Te_____

ILLUMINATION DEVICE-La_____

AUDIO EQUIPMENT-St_____

FURNITURE-Ar_____

CLOTHING-Tr_____

TOOL-Ha_____

WRITING IMPLIMENT-Fo_____

SPORTS EQUIPMENT-Ho_____

MUSICAL INSTRUMENT-Gu_____

APPENDIX H

Appendix H1

NRP-Similar to RP+ Condition

Experiment 4: Single factor within subjects ANOVA for NRP-Similar to RP+ condition

Source	SS	df	MS	F	Sig	Eta Sq
Items	7.911	3	2.637	30.443	.001	.512
Error	7.536	87	.087			

Experiment 4: Paired samples t-test for NRP-Similar to RP+ condition

	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
RP+ v NRP-Dis	.361	.409	.075	.208	.514	4.834	29	.001
RP- v NRP- Dis	-.307	.405	.074	-.458	-.156	-4.159	29	.001
NRP-Sim v NRP-Dis	-.213	.507	.093	-.403	-.024	-2.303	29	.029

Appendix H2

NRP-Similar to RP- Condition

Experiment 4: Single factor within subjects ANOVA for NRP-Similar to RP-condition

Source	SS	df	MS	F	Sig	Eta Sq
Items	8.469	3	2.823	26.145	.001	.474
Error	9.393	87	.108			

Experiment 4: Paired samples t-test for NRP-Similar to RP- condition

	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
RP+ v NRP-Dis	.397	.464	.083	.236	.583	4.833	29	.001
RP- v NRP- Dis	-.294	.471	.086	-.457	-.105	-3.265	29	.002
NRP-Sim v NRP-Dis	-.203	.520	.101	-.397	.009	-2.136	29	.041

Appendix H3

Between Subjects Comparisons

Experiment 4: Single factor between subjects ANOVA

Source	SS	df	MS	F	Sig	Eta Sq
Items	.116	2	.058	.628	.536	.014
Error	8.015	87	.092			

APPENDIX I

Appendix II

Independent Probe Method

CLOTHING-J _____

FURNITURE-B _____

COOKWARE-M _____

PHOTOGRAPHY EQUIPMENT-C _____

ART-P _____

BAGGAGE-R _____

FURNITURE-T _____

CLOTHING-L _____

FRAGRANCE-P _____

CONTAINER-V _____

TIME PIECE-C _____

GAME-P _____

CLOTHING-S _____

FURNITURE-D _____

COMMUNICATIONS DEVICE-M _____

MAGNIFICATION EQUIPMENT-T _____

ILLUMINATION DEVICE-L _____

AUDIO EQUIPMENT-S _____

FURNITURE-A _____

CLOTHING-T _____

TOOL-H _____

WRITING IMPLIMENT-F _____

SPORTS EQUIPMENT-H _____

MUSICAL INSTRUMENT-G _____

Appendix I2

Additional Questioning and Misinformation Phase

Non-critical Questions

Thompson's House

1. How old is the Thompson's daughter?
2. What time of year did the Thompson's go on holiday?
3. What type of vehicle did the police suspect the burglar or burglars of the Thompson's house had been driving?
4. For how long did the Thompson's go on holiday?
5. How many items where stolen from the Thompson's dining room?
6. Where did the Thompson's go on holiday?
7. What is the Thompson's daughter called?
8. Where do the Thompson's live?
9. What is Mr. Thompson's job?
10. How many items where stolen from the Thompson's sitting room?
11. How did the burglar or burglars break into the Thompson's house?

Williams' House

1. What is Mrs. Williams' job?
2. What time of year where the Williams' burgled?
3. What was the weather like the day the Williams' were burgled?

4. When did the Williams' get home?
5. How many items were stolen from the Williams' study?
6. What is the Williams' son called?
7. How did the burglars break into the Williams' house?
8. How many burglars do the police suspect broke into the Williams' house?
9. How many items were stolen from the Williams' bathroom?
10. Where do the Williams' live?
11. How old is the Williams' son?

Critical Questions

Thompson's House

1. In the Thompson's House, this shirt had been hung up on a hook on the back of a door, but what room was it stolen from?
2. In the Thompson's House, the pearls had been in a red presentation box, but what room were they stolen from?
3. In the Thompson's House, the rocking chair had been by the patio doors, but what room was it stolen from?
4. In the Thompson's House, the tennis racket had been in a cupboard, but what room was it stolen from?
5. In the Thompson's House, the Nintendo had been lying on the floor, but what room had it been stolen from?

Williams' House

1. In the Williams' House, the denim jacket had been hung up on a hook on a wall, but what room was it stolen from?

2. In the Williams' House, the engagement ring was left by the sink, but what room was it stolen from?
3. In the Williams' House, the filing cabinet had been by the door, but what room was it stolen from?
4. In the Williams' House, the Walkman had been lying on a shelf, but what room was it stolen from?
5. In the Williams' House, the screwdriver had been lying on the floor, but what room had it been stolen from?

Appendix I3

Forced-choice Recognition Test

Which of these items were stolen from the Thompson's house:

- | | | |
|-----------------|---------------|---------------|
| 1. hockey stick | tennis racket | golf clubs |
| 2. Nintendo | Playstation | Game Boy |
| 3. sweater | skirt | shirt |
| 4. bracelet | pearls | necklace |
| 5. sofa | armchair | rocking chair |

Which of these items were stolen from the Williams' house:

- | | | |
|-----------------|-------------------|----------------|
| 1. Discman | stereo | Walkman |
| 2. hammer | chisel | screwdriver |
| 3. denim jacket | waterproof jacket | leather jacket |
| 4. signet ring | engagement ring | wedding ring |
| 5. bookcase | drawers | filing cabinet |

APPENDIX J

Appendix J1

NRP-Similar to RP+ Condition

Experiment 5: Single factor within subjects ANOVA for NRP-Similar to RP+ condition

Source	SS	df	MS	F	Sig	Eta Sq
Items	5.905	3	1.968	18.925	.001	.395
Error	9.049	87	.104			

Experiment 5: Paired samples t-test for NRP-Similar to RP+ condition

	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
RP+ v NRP-Dis	.272	.472	.086	.010	.448	3.159	29	.004
RP- v NRP- Dis	-.308	.381	.070	-.450	-.165	-4.419	29	.001
NRP-Sim v NRP-Dis	-.207	.549	.100	-.412	.026	-2.071	29	.047

Appendix J2

NRP-Similar to RP- Condition

Experiment 5: Single factor within subjects ANOVA for NRP-Similar to RP-condition

Source	SS	df	MS	F	Sig	Eta Sq
Items	5.479	3	1.826	21.106	.001	.421
Error	7.528	87	.087			

Experiment 5: Paired samples t-test for NRP-Similar to RP- condition

	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
RP+ v NRP-Dis	.310	.441	.080	.1453	.474	3.851	29	.001
RP- v NRP- Dis	-.209	.382	.070	-.352	-.066	-2.994	29	.006
NRP-Sim v NRP-Dis	-.215	.374	.068	-.355	-.075	-3.146	29	.004

Appendix J3

NRP-Dissimilar Condition

Experiment 5: Single factor within subjects ANOVA for NRP-Dissimilar condition

Source	SS	df	MS	F	Sig	Eta Sq
Items	4.717	3	1.572	19.347	.001	.400
Error	7.070	87	.081			

Experiment 5: Paired samples t-test for NRP-Dissimilar condition

	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
RP+ v NRP-Dis	.299	.406	.074	.147	.451	4.033	29	.001
RP- v NRP- Dis	-.197	.424	.077	-.355	-.038	-2.540	29	.017
NRP-Sim v NRP-Dis	-.174	.435	.079	-.337	-.012	-2.195	29	.036

Appendix J4

RP- Condition

Experiment 5: Single factor within subjects ANOVA for RP- condition

Source	SS	df	MS	F	Sig	Eta Sq
Items	6.794	3	2.265	23.293	.001	.445
Error	8.459	87	.010			

Experiment 5: Paired samples t-test for RP- condition

	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval		t	df	Sig (2- tailed)
				Lower	Upper			
RP+ v NRP-Dis	.334	.414	.076	.179	.488	4.419	29	.001
RP- v NRP- Dis	-.262	.491	.090	-.446	-.079	-2.928	29	.007
NRP-Sim v NRP-Dis	-.229	.445	.081	-.395	-.063	-2.822	29	.009

Appendix J5

Between Subjects Comparisons

Experiment 5: Single factor between subjects ANOVA

Source	SS	df	MS	F	Sig	Eta Sq
Items	.157	4	.039	.422	.793	.011
Error	13.538	145	.093			

Appendix J6

Experiment 5: Omnibus chi square analysis and Phi value

	Value	df	Sig
Pearson Chi Sq	22.605	4	.001
N	150		
Phi	.388		.001

Appendix J7

Experiment 5: Chi square analysis and Phi value for NRP-Similar to RP+ condition

	Value	df	Sig
Pearson Chi Sq	6.239	1	.012
N	60		
Phi	-.322		.012

0 cells have expected count less than 5. The minimum expected count is 12.60

Experiment 5: Chi square analysis and Phi value for NRP-Similar to RP- condition

	Value	df	Sig
Pearson Chi Sq	15.429	1	.001
N	60		
Phi	-.507		.001

0 cells have expected count less than 5. The minimum expected count is 12.50

Experiment 5: Chi square analysis and Phi value for RP- condition

	Value	df	Sig
Pearson Chi Sq	10.335	1	.001
N	60		
Phi	-.415		.001

0 cells have expected count less than 5. The minimum expected count is 11

Appendix J8

Experiment 5: Chi square analysis and Phi value comparing NRP-Similar to RP+ with NRP-Similar to RP- conditions

	Value	df	Sig
Pearson Chi Sq	2.443	1	.118
N	60		
Phi	-.202		.118

0 cells have expected count less than 5. The minimum expected count is 13

Experiment 5: Chi square analysis and Phi value comparing NRP-Similar to RP+ with RP- conditions

	Value	df	Sig
Pearson Chi Sq	.601	1	.438
N	60		
Phi	-.100		.438

0 cells have expected count less than 5. The minimum expected count is 14.50

Experiment 5: Chi square analysis and Phi values comparing NRP-Similar to RP-
with RP- conditions

	Value	df	Sig
Pearson Chi Sq	.635	1	.426
N	60		
Phi	.103		.426

0 cells have expected count less than 5. The minimum expected count is 11.50

Appendix J9

Experiment 5: Chi square analysis and Phi value for NRP-Dissimilar condition

	Value	df	Sig
Pearson Chi Sq	.417	1	.519
N	60		
Phi	-.083		.519

0 cells have expected count less than 5. The minimum expected count is 6